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ORIGINAL ARTICLES

ROOTSTOCK EFFECT ON THE FRUIT QUALITY OF MALTA ORANGE (*CITRUS SINENSIS* OSBECK)

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(Received for publication on 7 August 1953)

(With two text-figures and Plates I to III)

It is well known that rootstocks affect the hardiness, the rate of growth, the size and shape of the top, the precocity, the prolificness, the time of ripening of fruit, the juice content, the amount of rind, the acidity, the sugar content and the flavour of citrus fruits. There is hardly a problem in citriculture, therefore, more worthy of painstaking and thorough investigation than that relating to rootstocks and their adaptability to soil, their compatibility to scion, their disease-resistance quality and their influence on crop production and quality of fruit. For determining the most suitable rootstocks and for testing their idiosyncracies for all kinds of citrus fruit grown in Punjab, rootstock investigations were first started at Lyallpur in 1932 by the Fruit Section of the Punjab Department of Agriculture. A few years later, with the financial assistance of the Imperial (now Indian) Council of Agricultural Research, well-planned citrus rootstock trials were laid out at the Horticultural Research Sub-Station, Montgomery—a place about 200 miles from Lyallpur (both these places being now in West Pakistan). Very useful results of great practical importance have already been reported from the work done at this research sub-station. The influence of different rootstocks on the vigour and cropping of Malta oranges, mandarin (*Sangtra*) and grapefruit has been studied in detail and useful recommendations made to growers and nurserymen [Lal Singh and Sham Singh, 1942 and 1944 ; Sham Singh, 1942 and 1944 ; Sham Singh and Nagpal, 1947 ; Khan and Musahib-ud-Din, 1949]. The present studies relating to the effect of some important rootstocks on the fruit quality of Malta oranges are a part of the investigations carried out during 1943-45 on the keeping quality of some important citrus fruits as influenced by different rootstocks [Kirpal Singh, 1945]. It has been found that rootstock is one of the important factors that influence the fruit quality of Malta orange, which in turn has a profound influence on the keeping quality of fruit.

Review of literature reveals that quite a good deal of work has been done in other countries on the influence of different rootstocks on the quality of citrus fruits. Provan [1933], Quinn [1934], Hall [1943], Marsh and Cameron [1950] and Kebby [1950] working on citrus rootstocks in Australia found that different rootstocks influence the size, texture, flavour and the chemical composition of fruit. Richards [1940] working in Ceylon reported marked influence of different rootstocks on the quality of citrus fruits. Fudge [1940], Halma [1943], Sinclair and Bartholomew [1944], Haas [1945 and 1948], Smith, Reuther and Specht [1949], *Anon.* [1951], Bitters [1951], Bitters and Batchelor [1951] and Batchelor and Bitters [1952] working on citrus rootstock problems in the United States of America reported

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interesting results relating to stock influence on the size and quality of citrus fruits and on the chemical composition of fruits, peels, flowers and leaves.

Results relating to the influence of different rootstocks on the quality of Malta Common and Malta Blood Red fruits—the two most important varieties of Malta orange grown in the Punjab, are reported in this paper to augment the already useful information emerging from time to time from the field trials in progress at the Horticultural Research Sub-Station, Montgomery. It is to be hoped that the present findings will make an important contribution to our existing knowledge of rootstock effects and that in considering the suitability of rootstocks for the two important Malta orange scions, the question of fruit quality will not be lost sight of in the future development of the orange industry in our country.

Material

Two important varieties of Malta orange (*Citrus sinensis* Osbeck), viz. Common and Blood Red growing on different rootstocks at the Horticultural Research Sub-Station, Montgomery, were selected to study the rootstock effect on the fruit quality of oranges. Malta Common—the most widely cultivated orange in the Punjab, is a heavy bearing variety and its fruit is quite juicy and pleasant to taste. Blood Red is the choicest and finest quality variety grown in the Province and is relished very much for its attractive red-coloured flesh, pleasant taste, rich and agreeable aroma and for these reasons commands a premium over all other varieties in the market. The fruit of both these varieties was picked towards the end of February 1944 from eight-year old trees which had almost reached the prime and peak of their yielding capacities.

Fruit of Malta Common variety was picked from eight-year old trees growing on five different rootstocks, viz.

(i) Rough lemon or '*Jatti khatti*'

(ii) *Kharna khatta*

(iii) *Nasnaran*

(iv) Sweet lime or *Mitha*

(v) Citron or *Mokari*

Fruit of Blood Red variety was picked from eight-year old trees which were growing on four different rootstocks, viz.

(i) Rough lemon or *Jatti khatti*

(ii) *Kharna khatta*

(iii) *Jullunduri khatti*

(iv) Sweet lime or *Mitha*

The morphology and other characters of the rootstock varieties employed in this study along with some others in the collection have been studied and described

in detail in order to clarify their nomenclature by Sham Singh [1951]. The distinguishing names of various rootstock varieties employed in the present investigations are, however, given in Table I.

TABLE I

Distinguishing names of the rootstock varieties under reference

Popular local name in the Punjab	English equivalent	Specific name
Jatti khatti	Rough lemon	*Citrus lemonia* Osbeck.
Kharna khatta	— nil —	*Citrus karna* Raf.
Mitha	Sweet lime	*Citrus aurantifolia* var. Swingle
Mokari or *Turanj*	Citron	*Citrus medica* Linn.
Jullunduri khatti	Smooth lemon	*Citrus* sp.
Nasnaran (received under this name from Ceylon)	— nil —	*Citrus* sp.

While picking the fruit of each scion/stock treatment, five trees were selected. Thus two hundred fruits for each rootstock treatment or 40 fruits from each tree were picked from all the four sides, the top, the bottom and the interior of each individual tree so as to make the composite sample well representative of the entire fruit population of a tree. As the fruit had to be brought from Montgomery to Lyallpur by rail (a distance of about 200 miles), all necessary precautions were taken to pick the fruit carefully and pack it in wooden cases so as to enable the fruit to reach its destination in good condition.

METHODS

Since the quality of an orange fruit is commonly judged by its size, colour, shape and weight and as marked differences were noticeable in fruits from different stock/scion treatment detailed observations were made to study the effect of different rootstocks on these general quality characters of the fruit. Physico-chemical analyses were conducted to study the effect of different rootstocks on :

(*a*) Volume (size) of fruit

(*b*) Density of fruit (determined both in case of whole fruits and the endocarp after removing the peel)

(*c*) Percentage of peel

(*d*) Percentage of juice

(*e*) Percentage of total soluble solids (sugars)

(*f*) Percentage of acidity

One dozen fruits were taken at random from each lot of 200 fruits representing each scion/stock treatment for the above-mentioned analytical work.

The volume (size) of the fruit was determined by water displacement method. The density of the whole fruit was determined by the usual method of weighing the fruit and then measuring its volume by the water displacement method and finally dividing the weight by volume. The density of endocarp was determined by the method of differences, viz. finding out the weight of the endocarp by subtracting the weight of peel from the weight of whole fruit and similarly the volume of endocarp was found by deducting the volume of peel from the volume of whole fruit. Finally, the weight of endocarp was divided by its volume for determining its density.

Juice percentage was determined by extracting the juice with the help of an electric driven cone, commonly known as Mixmaster. The extracted juice was strained through muslin cloth to remove seeds and particles of *rag* and then weighed for finding out the juice percentage.

The percentage of total soluble solids (sugars) was determined by using Abbe's Hand Refractometer. The sample of juice for this purpose was taken from the strained lot.

The percentage of acidity was determined in terms of citric acid by titrating the juice against N/10 NaOH, using phenolphthalein as the indicator. The fruit juice was diluted to lighten its colour by the addition of sufficient quantity of distilled water. The appearance of the pink colour indicated the end point.

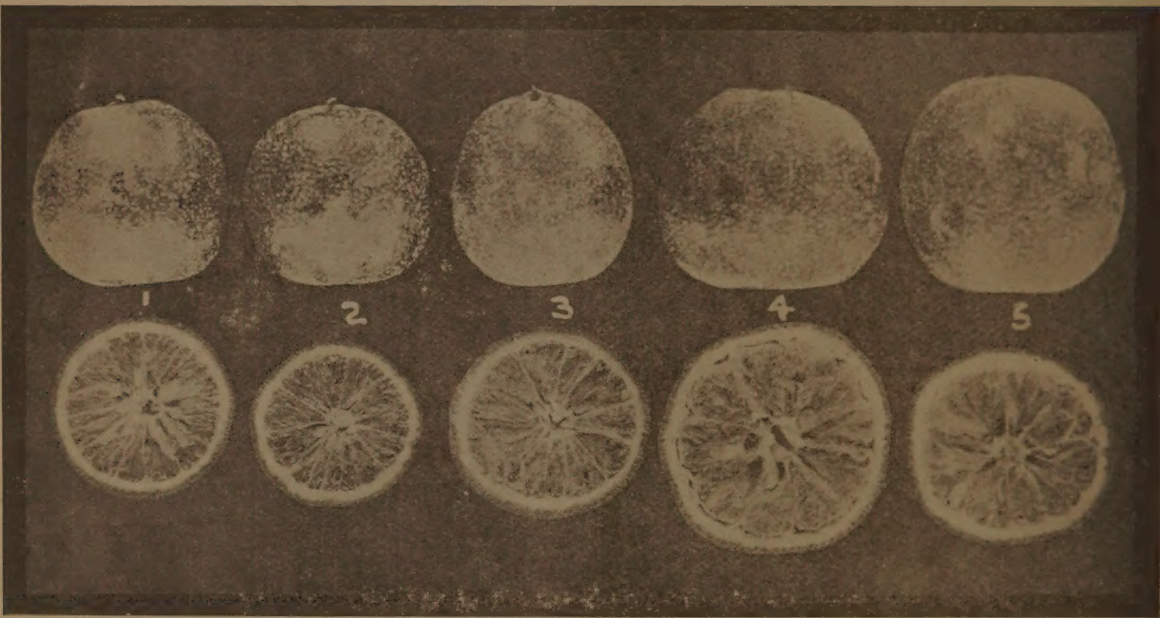
Results

To study the effect of different rootstocks on the fruit quality of Malta oranges, the fruit was picked from eight-year old trees growing on different rootstocks at the Horticultural Research Sub-Station, Montgomery and brought to the Fruit Section Laboratories of the Punjab Agricultural College and Research Institute, Lyallpur. On arrival, the fruit was unpacked and divided into different lots according to scion/stock treatments. For easy comparison, physico-chemical data regarding fruits of both Malta orange varieties from different rootstocks have been tabulated and presented together.

Rootstock effect on the general quality characters of fruit

The quality of Malta orange fruit is commonly judged by its size, colour, shape and weight. As a rule, small and medium-sized fruits with attractive colour and uniform shape are considered superior in quality and hence fruits possessing these characteristics are always in much greater demand in the market than the extra large-sized, dull-coloured (with sun-burnt spots) and mis-shapened fruits.

(*a*) *The general appearance of the fruit.* As marked differences were noticeable in the size, colour and general appearance of fruit within the same variety, evidently as a result of rootstock treatment, the observations with regard to these characters were made when these fruits were viewed in heaps of 200 fruits each representing different scion/stock treatments and a summary of these observations is provided in Table II.



Malta Common fruits (along with their transversely cut halves) as affected by different rootstocks

1. Malta Common fruit on *Nasnaran* rootstock
2. Malta Common fruit on rough lemon rootstock
3. Malta Common fruit on *Kharna khatta* rootstock
4. Malta Common fruit on Sweet lime rootstock
5. Malta Common fruit on Citron rootstock

TABLE II

Effect of different rootstocks on the general appearance of Malta oranges

Scion variety	Rootstock	Observations
Malta Common	Rough lemon	Fruits were of good average size with uniform shape and appearance and with well developed orange colour. The peel was shining and soft to touch and fruits were quite weighty thereby indicating their juicy character.
	Kharna khatta	Fruits in this lot had characters similar to those described under rough lemon rootstock above with the only difference that the size of fruit appeared to be comparatively larger in this case.
	Nasnaran	Fruits were of uniform size and shape. The peel was smooth with attractive orange colour. All fruits were weighty and appeared quite juicy.
	Sweet lime	Most of the fruits were abnormally large in size. The skin was coarse and puffy to touch. Some fruits appeared quite light in weight for their size and thereby giving an indication of their being deficient in juice.
	Citron	Fruits were as large in size as fruits from sweet lime rootstock. The skin, however, was comparatively more coarse and appeared to be less adherent to the endocarp.
Malta Blood Red	Rough lemon	Fruits were of average size with attractive appearance and uniform deep orange colour of the skin. Some fruits depicted a characterisitic red blush on the skin characteristic of this variety. The skin was smooth and the fruits were quite weighty.
	Kharna khatta	Fruits were smallest in size as compared to fruits in other lots but the red blush over the skin was most pronounced in this case.
	Jullunduri khatti	Fruits were of larger size than fruits from rough lemon lot and the skin was also more coarse.
	Sweet lime	Fruits were of large size but it was not so much as induced by this rootstock in case of Malta Common scion.

(*b*) *Examination of the whole as well as the transversely cut fruits.* A glance at the photograph of the whole and the transversely cut fruits of Common Malta (Plate I) would show that rough lemon rootstock has resulted in the production of medium-sized fruit with a thin albedo wall and a compact structure of the endocarp, that is, the juice sacs are tightly bound and the segments (carpels) constitute a compact mass with practically no hollow space in the centre. Next, in attactiveness are the fruits from the *Nasnaran* and *Kharna khatta* treatments where compactness of segments and juice sacs is almost of the same character as from the rough

lemon treatment but the central cavities in both these cases are comparatively larger. Fruits from the other two rootstock treatments, viz. sweet lime and citron are of abnormally large size, coarse and thick-skinned with a loose structure of the juice sacs some of which appear to be completely dry. They have also large cavities in the centre and a hollow space in between the segments and the thick albedo walls. Thus a mere superficial examination of the transversely cut fruits indicates that fruits from rough lemon, *Nasnaran* and *Kharna khatta* rootstock treatments are of a superior quality to those from the sweet lime and citron rootstock treatments.

The Malta Blood Red fruits as shown in the photograph (Plate II) from the two rootstock treatments, viz. rough lemon and *Kharna khatta* are of medium size and compact structure as compared with the large-sized fruits from the other two treatments, viz. *Jullunduri khatti* and Sweet lime. The fruits from both these treatments are coarse-skinned with thick albedo walls.

(c) *The percentage of juicy, partially juicy and non-juicy fruits.* To specify the extent of juice in the fruit, the terms juicy, partially juicy and non-juicy are used in a comparative sense only. The fruits showing a fresh and juicy condition of the juice sacs in the transversely cut halves is termed 'juicy', the partially juicy sacs, presenting an appearance of dryness marked by comparatively light colour are characteristic of 'partially juicy' fruit; and the juice sacs with predominantly light colour and absence of juice are characteristic of 'non-juicy' fruits. Size for size, a juicy fruit will weigh more than a partially juicy or a non-juicy fruit. Fifty fruits were used for each of the five rootstock treatments in case of Malta Common and four treatments in case of Malta Blood Red. The percentage of juicy fruits from the various rootstock treatments is given in Table III and also graphically illustrated in Fig. 1 and Fig. 2.

TABLE III

Effect of rootstock on the percentage of juicy, partially juicy and non-juicy fruits

Scion variety	Rootstock	Percentage of Juicy fruit	Partially juicy fruits	Non-juicy fruits
Malta Common	Rough lemon	94·0	6·0	—
	Kharna khatta	74·0	24·0	2·0
	Nasnaran	92·0	8·0	—
	Sweet lime	54·0	32·0	14·0
	Citron	52·0	34·0	14·0
Malta Blood Red	*Rough lemon*	94·0	4·0	2·0
	Kharna khatta	66·0	22·0	12·0
	Jullunduri khatti	84·0	14·0	2·0
	Sweet lime	94·0	6·0	—

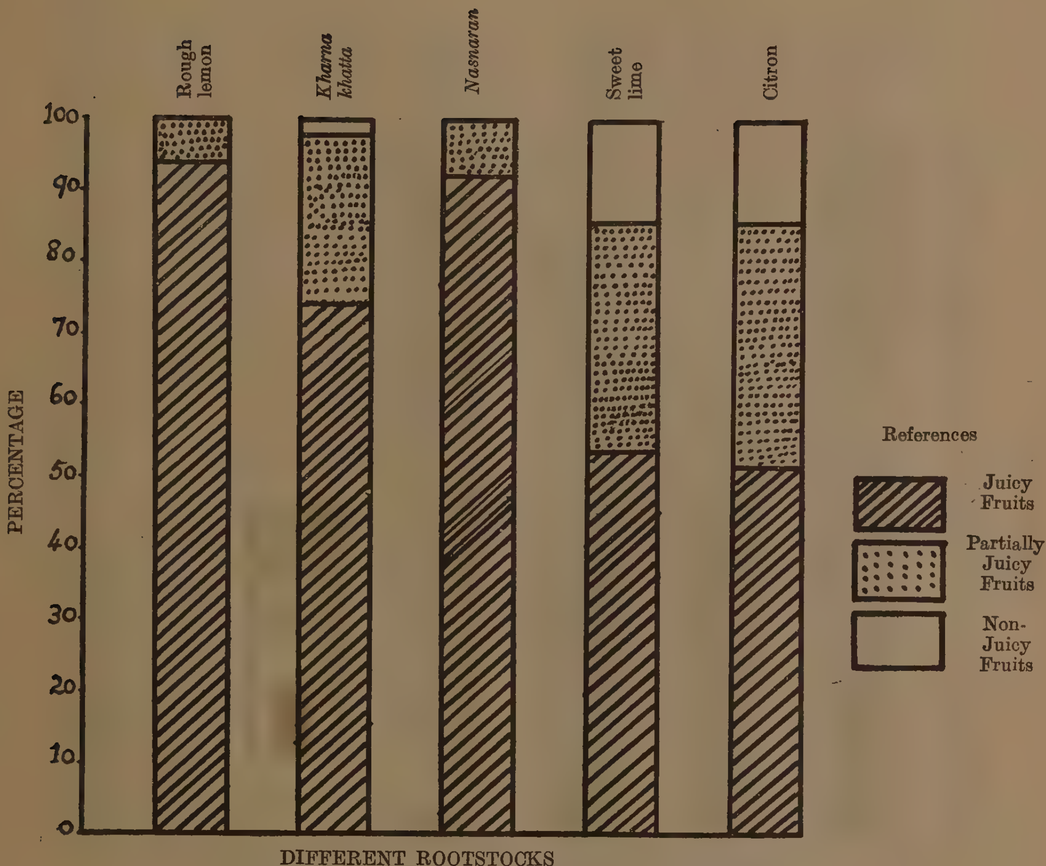


Fig. 1. Effect of rootstock on the juiciness of Malta Common fruits

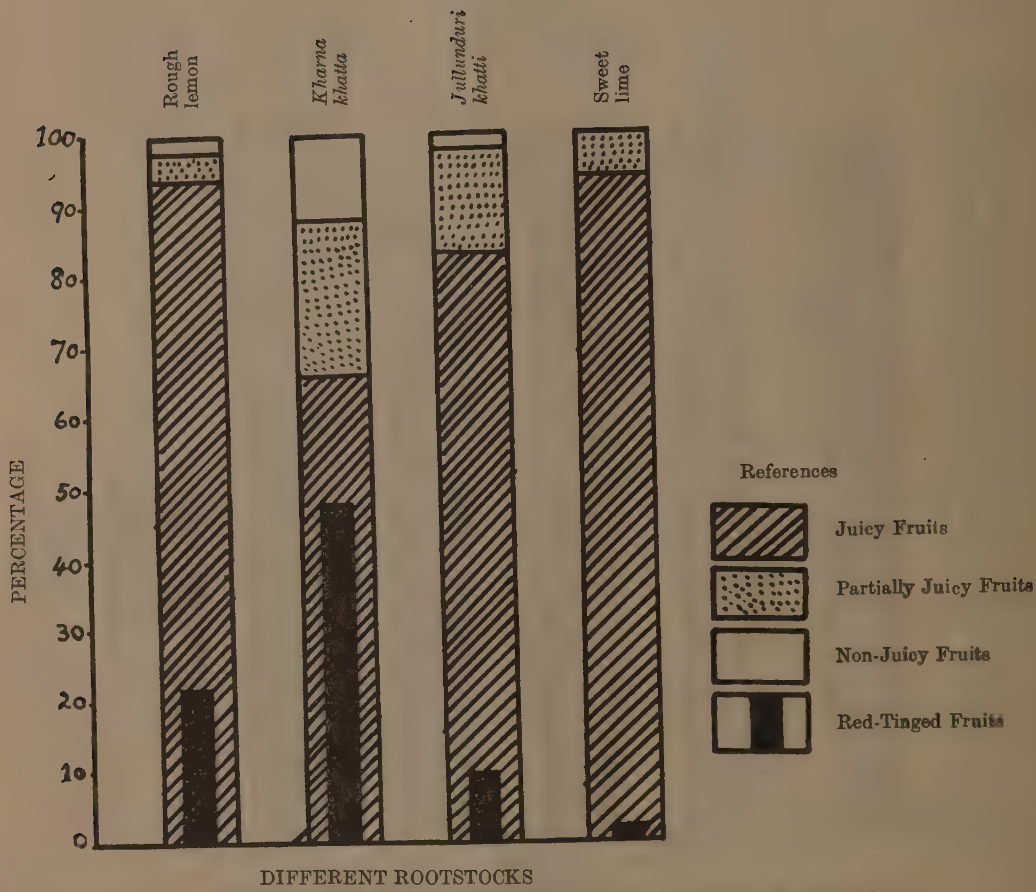


Fig. 2. Effect of rootstock on the juiciness and the colour of Malta Blood Red fruits

The salient features brought out by the figures are :

(*i*) The percentage of juicy fruits is high in both the scion varieties except for all the rootstocks under trial. Comparatively speaking this percentage is fairly low in case of Malta Common on sweet lime and citron rootstocks and in case of Malta Blood Red scion on *Kharna khatta* rootstock.

(*ii*) The percentage of non-juicy fruits is negligible in case of both the scion varieties but comparatively speaking this percentage is fairly high in case of Malta Common on sweet lime and citron rootstocks and in case of Malta Blood Red scion on *Kharna khatta* rootstock.

(*iii*) Rough lemon rootstock has produced fruits with a high percentage of juice in case of both the Malta scion varieties.

(*iv*) *Nasnaran*, used as a rootstock only in case of Malta Common, has proved as superior for producing juicy fruits as rough lemon.

(*v*) *Kharna khatta* and sweet lime rootstocks have produced different results in case of different scions as for instance, the former has produced satisfactory results only in case of Malta Common and the latter only in case of Malta Blood.

(*vi*) *Jullunduri khatti* which was used as a rootstock only in case of Malta Blood, has produced quite a high percentage of juicy fruits.

On comparing the characteristics of fruits under different rootstock treatments, as shown by the photographs (Plates I and II) with the data given in Table III for the percentage of juicy, partially juicy and non-juicy fruits, it is obvious that the larger the fruit, the thicker is the rind, the hollower is the central cavity and lesser is the percentage of juicy fruits. Exception to the above mentioned generalization is in the case of Malta Blood Red fruits on *Kharna khatta* rootstock which in spite of their apparently small size were found to have a fairly low percentage of juicy fruits. This exception may be explained by the fact that *Kharna khatta* rootstock is not quite compatible with Blood Red Malta scion [Lal Singh and Sham Singh, 1944] and as a result of this the trees shed leaves early in winter thus upsetting the nutritional balance of the tree and restricting the development of fruit and its proper attainment of quality (Plate III).

(*d*) *Development of red colour in the Blood Red Malta fruits as influenced by different rootstocks.* Transversely cut halves of the fruits used in the study of the percentage of juicy, partially juicy and non-juicy fruits in Blood Red Malta were also examined for the presence and intensity of red colour. This was found to be most pronounced in fruits under *Kharna khatta* rootstock treatment followed by rough lemon and *Jullunduri khatti* rootstocks. There was almost a complete absence of this colour in case of fruits under sweet lime rootstock treatment. A quantitative study of the red-tinged fruits in case of Malta Blood Red influenced by different rootstocks can be made from the figures given in Table IV.

TABLE IV

Influence of rootstock on the percentage of fruit showing the characteristic blood-red colour

Scion variety	Rootstock	Percentage of red-tinged fruits
Malta Blood Red	Rough lemon	22·0
	Kharna khatta	48·0
	Jullunduri khatti	10·0
	Sweet lime	2·0

Table IV and Fig. 2 show that *Kharna khatta* rootstock induces the development of red tinge to the greatest extent but this quality is eclipsed by its having produced a high percentage of less juicy fruits and also being incompatible with Malta Blood Red scion. The percentage of juicy fruits in case of rough lemon treatment is very high (94 per cent) and in view of this the low percentage of red-tinged fruits (22 per cent) cannot mar its value as an excellent rootstock for this scion. Nothing definite can be said at this stage regarding the remaining two rootstocks both of which are associated with the production of low percentage of red-tinged fruits. Detailed results regarding the factors responsible for the development of red colour in Blood Red Malta orange have already been reported in a previous publication by Kirpal Singh and Sham Singh [1948].

Effect on volume (size) of fruit

The quality of Malta orange fruit progressively deteriorates as the size increases. Consequently, medium-sized fruits are in much greater demand in the market than the large-sized or the under-sized fruits. The medium-sized fruits usually contain high percentage of juice, which amongst other things, is a factor that finds favour with the buyer.

The comparison of the fruit samples from different rootstocks for size was made by water displacement method. The volume was taken as a measure of the size of fruit. The detailed figures for the volume (size) of Malta Common and Malta Blood Red fruits as influenced by different rootstocks are given in Table V.

TABLE V

Effect of rootstock on volume (size) of Malta oranges

Scion variety	Rootstock	Average volume of fruit in c.c.
Malta Common	Rough lemon	245
	Kharna khatta	298
	Nasnaran	268
	Sweet lime	456
	Citron	333
Malta Blood Red	Rough lemon	215
	Kharna khatta	199
	Jullunduri khatti	254
	Sweet lime	277

Malta Blood Red fruits (along with their transversely cut halves) as affected by different rootstocks

1. Malta Blood Red fruit on *Kharna khatta* rootstock
2. Malta Blood Red fruit on *Jullunduri khatti* rootstock
3. Malta Blood Red fruit on Sweet lime rootstock
4. Malta Blood Red fruit on rough lemon rootstock

(Reproduced from *Indian J. agric. Sci.*, VOL. XVIII, Part II.)

(*Courtesy* Lal Singh & Sham Singh, 1944)

Blood Red on *Kharna khatta* rootstock. Note defoliation in all the three trees in the row during winter

The figures in Table V for the volume of Malta Common fruit in respect of various rootstock treatments reveal that fruits from sweet lime and citron rootstock treatments are large-sized (in terms of volume) followed by fruits from *Kharna khatta* rootstock treatment. The fruits from rough lemon and *Nasnaran* treatments are medium-sized. In the case of Blood Red Malta fruits from different rootstocks, the size of fruit from rough lemon and *Kharna khatta* treatments is smaller as compared with the fruit in case of *Jullunduri khatti* and sweet lime treatments. Comparatively speaking, fruits of Malta Common scion are bigger in size than Malta Blood Red irrespective of rootstock influence.

Effect on density of fruit

Although the absolute size of a particular variety of Malta orange fruit greatly helps to indicate its quality, yet the accurate determination of quality can only be made from its density—a comparison of weights per unit of size. A fruit may have a large size (volume) and at the same time a high percentage of juice. On the other hand a small-sized fruit may have a low percentage of juice. But when fruits in both the categories are compared on the basis of their densities, the comparison would provide a precise account of their respective qualities.

A comparison of the fruit samples from different rootstocks for density was made both in Malta Common and Malta Blood Red. The density was calculated as a ratio between the weight/volume and the density of fruit was studied both (*a*) on the whole fruit basis and (*b*) on the endocarp basis (eliminating peel). The figures are given in Table VI.

TABLE VI

Effect of rootstock on the density of Malta oranges

Scion variety	Rootstock	Density	
		On whole fruit basis	On endocarp basis
Malta Common	Rough lemon	0·86	0·97
	Kharna khatta	0·77	0·86
	Nasnaran	0·84	0·94
	Sweet lime	0·75	0·77
	Citron	0·74	0·79
Malta Blood Red	Rough lemon	0·83	0·91
	Kharna khatta	0·82	0·90
	Jullunduri khatti	0·76	0·86
	Sweet lime	0·79	0·88

(*a*) *Density on whole fruit basis.* On examining the figures in Table VI regarding density on the whole fruit basis, it is obvious that Common Malta fruit from rough lemon and *Nasnaran* treatments is much denser than fruit from the remaining three treatments. In case of Blood Red Malta fruits the density is comparatively more in case of rough lemon and *Kharna khatta* treatments than in the case of *Jullunduri khatti* and sweet lime treatments.

(*b*) *Density on endocarp basis.* The figures for density of the endocarp of fruit (peel removed) given in the last column of Table VI are consistently much higher than the corresponding figures for density of whole fruit. These differences are due to the fact that the peel, which is usually lighter than the internal juicy portion has been eliminated. A comparison of figures in Table VI for both the scion varieties would reveal that the juice content (density) is adversely affected by citron and sweet lime rootstocks in case of Malta Common and by none of the rootstocks in case of Blood Red scion. It may be mentioned here that sweet lime rootstock has been used for both the scions but its adverse effect on density is noticeable only in the case of Malta Common scion. The influence of rough lemon rootstock in increasing the density of fruit is most marked in case of both the scions.

Effect on percentage of peel

Different citrus fruits differ considerably with regard to the amount and character of peel or rind. Different varieties belonging to one kind or species often differ markedly in their peel content but the same has not been found in any way to be correlated with quality. The world's most renowned variety of sweet orange, viz. Jaffa from Palestine is comparatively much more coarse-skinned than the thin-skinned Californian variety—Valencia Late, which is equally famous. Furthermore, the fruits also differ considerably for peel content within one and the same variety with the result that thicker the rind the inferior the quality. It is this variation that matters most and one of the aims of this investigation was to find out the behaviour of different rootstocks on the peel content of Malta Common and Malta Blood Red.

The data on the percentage of peel have been determined both by weight and by volume and are set out in Table VII.

The figures in Table VII reveal that the percentage of peel by weight and by volume in case of Malta Common variety is markedly increased by sweet lime and citron rootstocks. Out of the remaining three rootstocks, *Kharna khatta* has also increased the peel content to a slight extent. The influence of *Kharna khatta* is more pronounced when peel percentage is expressed on volume basis. The behaviour of rough lemon and *Nasnaran* is almost identical in inducing lower peel percentage as studied in both the methods used for determining the peel content. In case of Blood Red scion, rough lemon is again characterised to have induced the least percentage of peel judged by both the standards of determination employed. The remaining rootstocks, viz. *Kharna khatta*, *Jullunduri khatti* and sweet lime fall almost in one and the same group, particularly when their peel percentages are determined by volume method.

TABLE VII

Effect of rootstock on the peel percentage of Malta oranges

Scion variety	Rootstock	Peel percentage	
		By weight basis	By volume basis
Malta Common	Rough lemon	37·0	39·3
	Kharna khatta	39·2	42·2
	Nasnaran	35·1	39·1
	Sweet lime	43·0	44·4
	Citron	42·4	46·8
Malta Blood Red	Rough lemon	36·7	39·8
	Kharna khatta	39·5	42·0
	Jullunduri khatti	39·0	44·3
	Sweet lime	37·8	41·6

Effect on percentage of juice

Within a particular variety the higher the percentage of juice the less is the amount of *rag* and consequently finer the quality of fruit. As a matter of fact, from the market stand-point the quality of Malta orange is often judged by its juice content. Ordinarily, a customer while buying oranges will ensure about the juice content of the fruit by roughly judging its weight. Such weightly fruits indicating their juicy character always command some premium over the apparently light fruits. This is so because the worth of Malta orange is in reality mainly based on its juice content, the other factors, viz. rind, *rag* and seed have in fact an adverse effect upon its market price.

The data regarding percentage of juice of fruits of Malta Common and Malta Blood Red scion on different rootstocks are summarised in Table VIII. To get a real comparison, the peel factor has been eliminated and the juice percentage has been expressed on the weight of the internal pulpy portion (endocarp) and not on the weight of whole fruit.

An examination of the figures in Table VIII shows a significantly higher percentage of juice in case of Malta Common, on rough lemon and *Nasnaran* rootstocks. *Kharna khatta* rootstock is mediocre in influencing the percentage of juice. On the other hand, fruits from sweet lime and citron rootstock treatments are much more deficient in juice. It is noteworthy to mention that the sweet lime rootstock induced a pale yellow colour to the juice of the fruit of the scion which was readily

TABLE VIII

Effect of rootstock on the juice percentage of Malta oranges (expressed on the endocarp of fruit)

Scion variety	Rootstock	Juice percentage
Malta Common	Rough lemon	64·9
	Kharna khatta	56·5
	Nasnaran	62·5
	Sweet lime	49·6
	Citron	50·6
Malta Blood Red	Rough lemon	64·2
	Kharna khatta	63·4
	Jullunduri khatti	59·0
	Sweet lime	63·0

distinguishable in contrast to the orange colour of the juice induced by the remaining rootstocks. In case of Malta Blood Red scion, the most outstanding rootstock for influencing a high juice content is rough lemon. The Blood Red fruits from *Kharna khatta* and sweet lime rootstocks are equally juicy and are next in order to fruits from rough lemon. On the other hand, the juice content induced by *Jullunduri khatti* rootstock is the least as compared to others.

Effect on percentage of total soluble solids (mainly sugars)

The sugar content of fruit is considerably responsible for its quality. The percentage of total soluble solids of the juice was determined by means of Abbe's Hand Refractometer and the data in respect of both the scions and different rootstocks are set out in Table IX.

TABLE IX

Effect of rootstock on the percentage of total soluble solids of juice of Malta oranges

Scion variety	Rootstock	Percentage of total soluble solids
Malta Common	Rough lemon	9·6
	Kharna khatta	8·2
	Nasnaran	9·0
	Sweet lime	7·8
	Citron	8·0
Malta Blood Red	Rough lemon	8·8
	Kharna khatta	9·0
	Jullunduri khatti	8·0
	Sweet lime	7·6

The figures for the percentage of total soluble solids which are mainly sugars, in Table IX reveal a marked effect of different rootstocks used. In case of Malta

Common the sugars are significantly increased by rough lemon and *Nasnaran* rootstocks in comparison with the rest. In case of Blood Red scion the rootstock effect in increasing the percentage of sugars in the juice is markedly noticeable in case of *Kharna khatta* and rough lemon in comparison with the other two. It is interesting to note that sweet lime rootstock has induced lower percentage of sugars in the juice when used with both the Malta scions.

Effect on the percentage of acidity

The right amount of acidity in the fruit of a given species is as important and desirable as the adequate amount of sugars present therein. In fact, it is the proper blend of sugars and acidity that generally determines the palatability of Malta orange fruit. The percentage of acidity in case of both the varieties of Malta orange has been expressed in terms of citric acid and the data are given in Table X.

TABLE X

Effect of rootstock on the percentage of acidity in juice of Malta oranges

Scion variety	Rootstock	Percentage of acidity
Malta Common	Rough lemon	0·62
	Kharna khatta	0·55
	Nasnaran	0·61
	Sweet lime	0·50
	Citron	0·51
Malta Blood Red	Rough lemon	0·61
	Kharna khatta	0·68
	Jullunduri khatti	0·59
	Sweet lime	0·63

The figures for the percentage of acidity (expressed in terms of citric acid) given in Table X show that this character is markedly influenced by rootstocks in both the varieties of Malta orange. In case of Malta Common, rough lemon and *Nasnaran* which markedly increase the percentage of sugars (*vide* data in Table IX) also increase significantly the percentage of acidity as compared with the remaining rootstocks. In case of Malta Blood Red also, *Kharna khatta* and rough lemon have again induced higher percentage of acidity. The effect of sweet lime rootstock is different this time. It has induced quite a higher percentage of acidity when used with Malta Blood Red scion but has induced least percentage of acidity when used with Malta Common.

Effect on sugar/acid ratio

It is generally found that in the early stages of maturity, almost all fruits and particularly citrus fruits contain a higher percentage of acidity which, as the ripening processes continue, decreases with or without a simultaneous increase in the percentage of total soluble solids (sugars). Hence, the ratio between these two independent factors goes a long way in determining the quality of fruits, particularly in the case of oranges. In the present investigation the sugar/acid ratio as affected by different scion/rootstock combination has also been worked out and the results are presented in Table XI.

TABLE XI

Effect of rootstock on the sugar/acid ratio of juice of Malta oranges

Scion variety	Rootstock	Sugar/acid ratio
Malta Common	Rough lemon	15·5
	Kharna khatta	14·9
	Nasnaran	14·7
	Sweet lime	15·6
	Citron	15·7
Malta Blood Red	Rough lemon	14·4
	Kharna khatta	13·2
	Jullunduri khatti	13·6
	Sweet lime	12·1

The figures in Table XI show a marked scion influence on the sugar/acid ratio of fruit, e.g. the values for Malta Common scion being higher than the corresponding values in case of Malta Blood Red. Notwithstanding this, the rootstock influence is also equally well marked in fruits from both the Malta orange scions.

Effect on the palatability of fruits

The palatability or the taste and flavour of fruit offer a precise expression of the sugar/acid blend along with characteristic volatile flavour in case of Malta orange. Other characters such as smoothness or wartiness of rind, the thinness or thickness of peel, the dryness or juiciness of juice-sacs and the size of fruit, individually, are only of secondary importance in determining the quality of Malta fruit as compared with its characteristic orange taste. A study of taste and flavour of Malta oranges as influenced by the use of different rootstocks was therefore considered very necessary in addition to other physico-chemical tests. Organoleptic tests

were therefore conducted with fruits representing different stock/scion treatments. For judging the fruit quality the points considered comprised the juiciness of fruit, characteristic orange flavour, freshness of taste and the proper sugar-acid blend as generally found in fresh fruits of excellent quality. For this, detailed views of a panel of tasters were recorded and the same have been summarised in Table XII.

TABLE XII

Effect of rootstock on the palatability of Malta oranges

Scion variety	Rootstock	Remarks regarding taste, etc.
Malta Common	Rough lemon	Very juicy with pleasant taste and rich orange flavour.
	Kharna khatta	Quite juicy but not as juicy as fruits from rough lemon. Good taste with good orange flavour.
	Nasnaran	Very juicy with pleasant sugar-acid blend. Very good taste with rich characteristic orange flavour.
	Sweet lime	Not as juicy as fruits from above rootstocks, more *rag* and coarse texture. Taste and flavour good.
	Citron	Same as fruits from Sweet lime rootstock.
Malta Blood Red	Rough lemon	Very juicy with agreeable sugar-acid blend. Taste and flavour very good.
	Kharna khatta	Quite juicy, taste and flavour good.
	Jullunduri khatti	Less juicy than fruits from rough lemon rootstock but with pleasant taste and rich orange flavour.
	Sweet lime	Quite juicy slightly less sweet than fruits from other rootstocks, otherwise had good flavour.

It has been found that *Nasnaran* and rough lemon rootstocks have induced a pleasant taste and rich flavour in case of Malta Common fruits. *Kharna khatta* rootstock comes next in order. The flavour and taste of fruit on sweet lime and citron rootstocks have been found slightly inferior to fruits from other rootstock treatments. In case of Blood Red scion, the rough lemon rootstock has been found to be the best for inducing pleasant taste and rich flavour to the fruit. In case of the remaining three rootstocks, viz. *Kharna khatta, Jullunduri khatti* and Sweet lime the taste and flavour of fruit was found next in order to rough lemon.

DISCUSSION

A comprehensive study of the effects of different rootstocks on the fruit quality of two important varieties of Malta orange (*Citrus sinensis* Osbeck), viz. Malta Common and Malta Blood Red has been made and the results obtained have been reported in the previous section. These results have brought to light many points

of academic interest as well as of practical significance, particularly in relation to the importance of rootstock influence in determining the fruit quality of Malta oranges on one hand, and the need for a radical change in some methods of procedure in comparing the rootstock influence on the other. Evidence has been gathered on a number of points that have either a direct or an indirect bearing on fruit quality and the important issues that have arisen therefrom are briefly discussed as follows.

Development of red colour in Malta Blood Red variety

The results presented on this phase of study have given a strong indication as to the individuality of the rootstock for inducing the red colour in Malta Blood Red variety, which was found to be most pronounced in case of *Kharna khatta* rootstock treatment followed by rough lemon and *Jullunduri khatti* rootstocks. There was almost a complete absence of this colour in case of fruits from sweet lime rootstock treatment. The outstanding difference in favour of *Kharna khatta* rootstock in developing the red colour in Blood Red variety is more apparent than real. It is not actually the influence of this rootstock as such, but it is, in reality, due to the effective exposure of the fruit to low temperatures on account of the defoliation of the trees on this rootstock in winter (Plate III) which allows low temperatures of the season to have full play on the exposed fruits. The factors responsible for the development of red colour in Blood Red orange have already been reported in detail by Kirpal Singh and Sham Singh [1948].

Size of fruit in relation to rootstock influence

The size of fruit has been observed to play a considerable part in influencing the fruit quality of Malta oranges. The size, it may be noted, was influenced significantly by the rootstocks used. The fruits of both the scion varieties were comparatively large-sized on sweet lime and those of Malta Common on citron rootstock also. These results corroborate the previous findings of Sham Singh [1944]. The fruits in the case of other rootstock treatments were medium-sized except that Blood Red fruits on *Kharna khatta* were rather small-sized. This exception may be explained in view of the fact that *Kharna khatta* rootstock is not quite compatible with Blood Red Malta scion [Lal Singh and Sham Singh, 1944] and as a result of this, the trees shed leaves early in winter thus upsetting the nutritional balance of the tree and restricting the development of fruit and its proper attainment of size (Plate III).

In the present investigation the rootstock influence on the size of fruit in case of Malta orange has been studied on volume basis and not on weight basis because a clear understanding can be had only by determination through volume basis. A Malta orange, with thin peel, and abundant juice may be of more weight than a large-sized and less juicy orange with thick puffy peel. In order to get a clear picture, therefore it is more correct to study the size effect on volume basis rather than on weight basis and particularly in cases where certain cultural practices have induced a marked size effect.

Density in relation to rootstock influence

A study of the densities of fruits showed that it is an indispensable factor for precisely determining the quality of Malta orange fruits. It has been found that fruits of higher densities, irrespective of size, were also associated with better quality. Malta Common fruits from rough lemon and *Nasnaran* rootstocks and Malta Blood Reds from rough lemon rootstock with higher densities have been found of outstanding qualities as compared to fruits from other rootstocks with lower densities. In view of these results, the comparison of citrus fruits for quality cannot be based on the study of absolute size alone as is commonly believed and generally practised. A fruit may have a larger size and at the same time a higher percentage of juice. On the other hand, a small-sized fruit may have a low percentage of juice. When, however, the comparison of different sizes of citrus fruits is made along with their densities a more definite criterion of their respective qualities can be established.

Peel content

The peel percentage of different kinds of fruits used in these studies was compared both on the weight and volume bases. This study has revealed beyond doubt that there is a marked influence of various rootstocks in inducing the peel percentage of fruits. Rough lemon and *Nasnaran* rootstocks in case of Malta Common and rough lemon rootstock in case of Malta Blood Red have produced fruits with low content of peel as compared with other rootstocks under trial. Similar results have previously been reported by Sham Singh [1944].

In view of the rootstock effect on the loose and puffy character of the peel, a thicker specimen of peel, size for size, may not be as heavy in proportion to its thickness as the thin specimen. But the volume of both the specimens of peel would be directly proportional to their thickness. Yet another point against the determination of peel percentage on fresh weight basis is that size for size the peel percentage in case of less juicy fruit would be more than in case of a comparatively more juicy fruit. On the other hand, there would be no difference in the volumes of these two fruits, thereby, giving a correct measure of the percentage of peel on volume basis in both cases. It is obvious, therefore, that in determining the rootstock effect on the percentage of peel, or otherwise, comparing the varieties of a particular kind of fruit for peel content, the method followed should be on volume basis. This in itself is an important contribution to the technique already in practice for comparing varieties or effects of other cultural practices for peel content on the fresh weight basis of citrus fruits.

Juice percentage

The juice content expressed on the weight of the endocarp of fruit was found to be considerably influenced by the kind of rootstock used in case of both the Malta orange scion varieties under study. The reason for expressing the juice percentage on the endocarp of fruit was to eliminate the variable factor of peel which was significantly influenced by the rootstock treatments. The juice percentage in case of citrus fruits is usually determined by expressing it on the fresh weight of whole

fruit but the evidence collected in these investigations leads to the conclusion that the method so far followed has not been accurate enough to obtain reliable results. It is to be expected, therefore, that the methods followed and suggested for future adoption in similar investigations in case of citrus fruits would be given a wide application in the interest of accuracy and reliability of results.

Palatability of fruit

The characteristic taste and flavour of a particular fruit has really a more important bearing on its profitable marketing than its mere external appearance. The market value of an orange is determined by its quality which is a function of its juice content, colour, texture of flesh, *rag* content, blend of sugars and acidity and the richness and character of aroma. All these factors collectively determine the taste and flavour of a particular variety of citrus fruit. In the present investigation all the different factors that go to constitute the quality of orange fruit have been studied separately in detail and the results reveal that in the same variety these factors are variably influenced by the kind of rootstock used. The superiority in taste and richness in flavour are the result of a combination of high acidity and high sugars besides having more juice and soft texture of the flesh, and these are the characteristics that are more favourably induced by certain rootstocks in the two Malta orange scions that have been studied. For instance, rough lemon, *Nasnaran* and *Kharna khatta* in case of Malta Common and rough lemon in case of Malta Blood Red, are the outstanding rootstocks which are characterised to have induced characters responsible for better palatability and finally the quality of Malta orange fruits in each case.

Summary

1. The influence of certain rootstocks on the fruit quality of two important varieties of Malta orange, viz. Malta Common and Malta Blood Red has been studied in detail during 1943-45 at the Fruit Section Laboratories, Punjab Agricultural College and Research Institute, Lyallpur. The fruits used in these trials were picked from eight-year old trees growing on different rootstocks at the Horticultural Research Sub-Station, Montgomery.

2. The development of red colour in Malta Blood Red has been found to be markedly influenced by the kind of rootstock used. The rootstocks influencing the red colour, arranged in the descending order of magnitude, are *Kharna khatta*, rough lemon, *Jullunduri khatti* and sweet lime.

3. The outstanding influence of *Kharna khatta* rootstock on the development of red colour has not been directly associated with it as such. It has been only indirectly responsible for this influence—this being caused by low atmospheric temperatures which played their full part on fruit borne upon defoliated Blood Red trees characteristic of *Kharna khatta* rootstock.

4. The size of Malta orange fruit, in case of both the scion varieties studied, was considerably influenced by the kind of rootstock used. The significant influence on size was observed due to citron and sweet lime rootstocks.

5. Medium-sized fruit, resulting from the effects of rootstocks other than sweet lime and citron, was found to be of higher density and better quality than the large-sized fruit.

6. The method of determining the density of fruit on the endocarp basis has been shown to be more reliable than that based on the weight of whole fruit.

7. The peel content in both the scion varieties was increased by the influence of those rootstocks which also increased the size of fruit.

8. The method of calculating the percentage of peel on volume basis of fruit has been shown to be more accurate than expressing it on weight basis.

9. The percentage of juice was markedly influenced by the kind of rootstock used. Rough lemon and *Nasnaran* rootstocks in case of Malta Common and rough lemon and *Kharna khatta* rootstocks in case of Malta Blood Red induced a higher juice percentage than the remaining rootstocks used in each case.

10. It has been shown that the method of determining the juice percentage on the endocarp basis is more accurate than expressing it on the weight of whole fruit.

11. The percentage of total soluble solids (sugars) was markedly influenced by certain rootstocks in both the scion varieties. For instance, rough lemon and *Nasnaran* rootstocks in case of Malta Common and rough lemon and *Kharna khatta* rootstocks in case of Malta Blood Red increased the percentage of sugars.

12. The percentage of acidity was markedly increased by those rootstocks which also induced a high percentage of sugars as mentioned above.

13. The fruit quality of Malta orange was markedly influenced by the kind of rootstock used. For instance, *Nasnaran*, rough lemon and *Kharna khatta* in case of Malta Common, and rough lemon in case of Malta Blood Red are characterised to have induced characters responsible for producing better quality fruits in each case.

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A STUDY ON THE DEVELOPMENT OF SALINITY IN CULTIVATED SOILS

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SALINITY of soils is an important factor of crop production in regions of scanty rainfall and alternate arid and humid soil climate. Even with moderate to heavy rainfall, salinity is often manifest in areas, where drainage is impeded through either impervious subsoil or high water table. The disrupting action of solar radiation on soil minerals is also of considerable importance in the development of salinity in soils. For instance the nature of soil minerals in some of the alluvial deposits of India is often a very important factor leading to excessive salt concentration in cultivated soils. Ordinarily crop growth can be expected to diminish, as in some cases it does, the concentration of salts in soils ; but in actual practice due to the nature and concentration of salts, the crop growth alone (even of salt-tolerant varieties) does not lead to the desired results.

Stewart [1918] showed that a large amount of soluble salts were developed by cultivation, fallowing and by biennial cropping. Metzgar [1927] observed that plants were able to exert a measurable solvent action on soil minerals through CO_2 respiration from their roots, which could be quantitatively measured [Lundegardh, 1924]. In cultivated soils, an additional source of soluble salts was sometimes the irrigation water [Taylor and Mehta, 1940].

That plant growth reduced salinity of soils was established by Stewart and Martin [1921] and Basu, *et al.* [1943]. Burd [1918] found that salt contents of uncropped soils were higher than cropped ones. Millar [1922] observed that the salt content of the surface soil changed with season. Burd and Martin [1924] pointed out that the decrease in salt concentration through continuous cropping was only temporary in nature, since the soils regained their original concentration of salts by the beginning of the next cropping season. Wright [1928] found that the specific conductivities of the soil extracts decreased through continuous cultivation.

Tulaikov [1922] who studied the change in the composition of the soil solution with crop growth adduced evidence to show the predominant effect of rainfall on the content and composition of soluble salts. Johnston [1925] found that in arid soils, crop growth retarded the formation of sulphates, while under humid conditions, it helped production of sulphates and their utilisation by subsequent crops.

It was observed by some workers that the salt of a soil could be correlated with the crop producing power of a soil, though the relationship was not very exact [Burd, 1918]. Sen [1932], from studies of increase in the conductivities of soil extracts with time, deduced that the rate of solution was proportional to the fertility of the soils. Millar [1923] suggested that the rate of solubility of the soil material decreased in cultivated soils.

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The study of the effect of crops on the content and composition of soluble salts is an important one in relation to development and state of salinity in cultivated soils. Such studies in the laboratory, however, can hardly simulate actual field conditions as adjustments of other factors like agricultural operations, natural drainage, irrigation, etc. are difficult under laboratory conditions. A comparison of the content and composition of the soluble salts of a large number of soils, cultivated and uncultivated from the same soil localities, probably offers the best means of making such a study.

Contents and composition of soluble salts of a large number of Indian virgin soils have already been reported by Sengupta and others [1946]. Along with the virgin soils, soils from adjoining cultivated fields had also been collected from the same localities. The present investigation, covering the determination of the contents and composition of soluble salts of 52 cultivated soils, up to a depth of two feet, brought from different parts of India was undertaken to find out the changes in the saline constituents of soils as a result of agricultural practices.

Materials and methods

Soils

The soils were collected up to a depth of two feet, so that there were two samples, surface and subsoil, representing a soil locality. A description of the soils, together with their mechanical composition and pH are given in Table I.

Table I

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	*p*H
Makrera (Ajmere-Merwara). *Grey sandy loam, subsoil more sandy than the surface*					
0—1	68·66	8·89	11·70	10·75	7·1
1—2	58·06	11·30	13·22	17·42	8·0
Tabiji (Ajmere-Merwara). *Brown sandy loam, little difference between the surface and the subsoil*					
0—1	88·14	1·47	9·50	0·89	8·6
1—2	88·18	5·89	4·02	1·91	7·9
Jorhat (Assam). *Old alluvial soil, reddish brown in colour*					
0—1	68·16	13·28	10·91	7·65	5·2
1—2	52·36	17·97	13·42	16·23	5·1

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	*p*H
Karimgunj (Assam). *Heavy alluvial soil, subsoil lighter in colour than the surface*					
0—1	12·24	15·92	49·61	22·23	5·8
1—2	22·92	15·67	39·55	22·92	5·9
Sylhet (Assam). *Alluvial soil, surface blackish and the subsoil brown in colour*					
0—1	62·73	15·08	14·35	7·84	5·1
1—2	54·83	11·53	20·43	13·21	4·9
Chinsurah (Bengal). *Heavy clay soil, subsoil lighter in colour than the surface*					
0—1	14·12	4·89	21·02	59·97	6·4
1—2	13·05	1·66	28·47	56·82	6·9
Rangpur (Bengal). *Light sandy alluvial soil, subsoil more sandy than the surface*					
0—1	19·62	24·79	44·72	10·87	6·4
1—2	8·40	26·46	52·48	12·66	6·7
Orai (Bihar). *Unmanured alluvial loam*					
0—1	8·36	20·99	26·47	44·18	7·6
1—2	13·59	17·67	25·96	42·78	7·8
Ranchi (Bihar). *Deep brown sandy soil, no difference in colour between the surface and the subsoil*					
0—1	45·65	12·92	24·10	17·33	6·9
1—2	41·71	9·47	26·71	22·11	6·8
Sabour (Bihar). *Paddy soil, greyish in colour, surface deeper in colour than the subsoil*					
0—1	19·88	36·10	30·40	13·62	7·2
1—2	12·65	32·22	29·51	25·82	7·3
Bijapur (Bombay). *Deep black soil, surface contains larger amounts of lime nodules than the surface*					
0—1	11·54	1·34	32·03	55·09	8·1
1—2	8·77	0·90	20·38	69·45	8·2

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	*p*H
Dharwar (Bombay). *Greyish black soil, subsoil more clayey than the surface*					
0—1	21·83	7·13	13·86	57·18	7·4
1—2	21·09	8·59	9·52	60·80	7·5
Kumpta (Bombay). *Disintegrated laterite, reddish in colour*					
0—1	41·28	4·10	18·82	35·80	6·3
1—2	52·83	7·26	20·91	19·00	6·6
Nadiad (Bombay). *Highland reddish soil, surface deeper in colour than the subsoil*					
0—1	51·18	7·40	13·74	27·68	7·5
1—2	45·43	6·12	16·29	32·16	7·6
Padegaon (Bombay). *Black soil, not much difference noted between the surface and the subsoil*					
0—1	16·32	9·99	31·24	42·45	7·2
1—2	3·69	6·74	21·32	68·25	7·4
Sholapur (Bombay). *Deep soil, uniformly black*					
0—1	0·00	2·25	18·04	79·97	7·4
1—2	4·11	2·61	13·24	80·04	7·5
Surat (Bombay). *Black soil below the wet surface soil, the soil is of transported nature*					
0—1	20·01	6·16	21·14	52·69	7·1
1—2	12·81	14·66	18·83	53·70	7·1
Akola (M. P.). *Deep black heavy soil*					
0—1	6·46	6·59	28·91	58·04	7·9
1—2	4·63	6·83	21·13	67·41	8·3

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	*p*H
Chandkhuri (M. P.). *Soil contains a large proportion of stones surface soil brown, subsoil reddish with more* kankar *than at the surface*					
0—1	26·85	9·31	29·09	34·75	6·4
1—2	22·87	7·16	20·26	49·71	6·1
Indore (M. P.). *Blackish surface and subsoil, presence of lime* kankars *throughout*					
0—1	8·25	9·15	20·05	62·55	7·5
1—2	4·60	8·67	27·59	59·14	7·6
Kharua (M. P.). *Black soil, presence of lime* kankars *throughout*					
0—1	19·22	13·22	32·82	34·73	7·6
1—2	18·89	11·00	18·82	51·29	7·8
Kheri (M. P.). *Light black soil, subsoil greyish, presence of lime nodules throughout*					
0—1	16·02	6·58	27·07	50·33	6·7
1—2	18·02	8·54	21·19	52·25	6·6
Nagpur (M. P.). *Typical black cotton soil, surface and the subsoil of the same colour*					
0—1	8·88	2·85	29·22	59·05	7·9
1—2	8·66	5·12	28·33	57·89	8·1
Powerkhera (M.P.). *Clay loam, greyish black in colour, contains lime nodules both at the surface and the subsoil*					
0—1	9·88	9·79	26·52	53·85	7·77
1—2	7·58	7·65	28·37	56·49	7·8
Waraseoni (M.P.). *Grey sandy loam, little difference between the surface and the subsoil*					
0—1	35·01	12·53	24·91	27·55	6·4
1—2	37·73	7·61	22·57	32·09	6·9

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	*p*H
Labhandi (M.P.). *Heavy soil, surface yellowish grey, subsoil red with occurrence of lime nodules*					
0—1	9·79	4·71	30·10	55·40	7·1
1—2	10·38	5·01	28·48	56·13	7·2
Aduturai (Madras). *Greyish black soil, subsoil more sandy than the surface*					
0—1	23·54	8·87	21·49	46·10	6·6
1—2	28·57	8·88	17·68	44·87	7·2
Anakapalle (Madras). *Irrigated wet land, alluvial, surface darker than the subsoil*					
0—1	46·12	13·17	12·33	28·38	6·8
1—2	54·68	5·15	13·68	26·49	6·7
Coimbatore (Madras). *Red soil, irrigated, subsoil darker than the surface*					
0—1	73·47	4·57	9·92	12·04	8·1
1—2	67·15	4·60	0·97	27·28	7·8
Hagari (Madras). *Black soil, little difference between the surface and the subsoil*					
0—1	35·12	4·36	17·39	43·13	8·2
1—2	22·61	9·94	23·62	43·83	8·1
Koilpatti (Madras). *Unmanured, unirrigated, red subsoil darker than the black colour of the surface*					
0—1	31·79	6·10	8·84	53·27	6·5
1—2	30·11	2·55	30·63	36·71	6·9
Samalkot (Madras). *Heavy soil, subsoil darker in colour than the surface*					
0—1	12·69	5·20	25·28	56·83	7·2
1—2	..	4·34	31·49	64·69	8·3
Taliparamba (Madras). *Red laterite*					
0—1	77·44	5·34	8·83	8·39	5·8
1—2	78·04	10·68	7·12	4·16	5·4

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (·02—·002 mm.)	Clay (less than 0·002 mm.)	*p*H
Haripur Hazara (N.W.F.P.). *Alluvial yellowish brown loam*					
0—1	15·60	20·21	43·22	20·97	7·3
1—2	11·54	12·67	62·92	12·97	7·4
Tarnab (N.W.F.P.). *Pinkish alluvial soil*					
0—1	19·54	27·35	40·95	12·16	7·8
1—2	18·36	33·25	38·99	9·40	8·2
Berhampur (Orissa). *Greyish soil, subsoil darker than the surface*					
0—1	69·04	7·00	11·27	12·69	6·8
1—2	53·47	3·20	10·78	32·55	7·0
Ferozepur (Punjab). *Yellowish grey soil, alluvial loam*					
0—1	5·90	39·03	46·36	8·71	7·7
1—2	8·68	34·00	47·84	9·48	7·6
Gurdaspur (Punjab). *Yellowish brown soil little difference between the surface and the subsoil*					
0—1	24·41	18·93	43·31	13·35	6·9
1—2	16·75	18·87	43·67	20·70	6·8
Guzranwala (Punjab). *Aeolian deposit, little or no difference between the surface and the subsoil*					
0—1	24·94	19·24	37·04	18·78	7·6
1—2	23·95	15·60	35·38	25·08	7·8
Kalashakaku (Punjab). *Greyish black soil, subsoil more clayey than the surface*					
0—1	14·73	17·51	45·91	21·85	8·1
1—2	10·58	17·99	43·81	27·62	8·1

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft.)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	pH
Kangra (Punjab). *Brownish black soil, characteristics of a soil from a high-rainfall region*					
0—1	55·59	10·08	28·00	6·33	6·2
1—2	53·13	15·81	20·70	10·31	6·1
Lahore (Punjab). *Yellowish brown alluvial loam*					
0—1	32·02	28·06	23·45	16·47	7·6
1—2	18·92	17·60	34·27	29·21	7·8
Lyallpur (Punjab). *Reddish yellow soil, light loam*					
0—1	44·32	15·31	22·81	17·56	7·6
1—2	44·33	17·57	22·17	15·93	7·9
Mianwali (Punjab). *Sandy loam, mixture of aeolian and alluvial deposits*					
0—1	64·86	11·62	15·73	7·79	8·2
1—2	48·44	9·46	27·99	14·11	8·3
Karachi (Sind). *Yellowish brown loam, surface slightly deeper in colour than the subsoil*					
0—1	38·91	6·59	33·86	20·64	8·0
1—2	40·93	16·64	27·01	15·42	8·3
Mirpurkhas (Sind). *Yellowish brown clay loam*					
0—1	17·33	12·01	31·23	39·43	7·7
1—2	5·71	10·55	38·92	44·82	8·1
Sakrand (Sind). *Pale brown, loam, surface deeper in colour than the subsoil*					
0—1	40·00	18·91	23·82	17·27	7·9
1—2	11·75	16·92	48·82	22·51	8·1
Aligarh (U.P.). *Alluvial brownish grey soil, unmanured, canal irrigated*					
0—1	44·82	17·29	17·88	20·01	7·4
1—2	37·37	16·63	21·93	24·07	7·6

TABLE I—(*contd.*)

Description and mechanical composition of soils from different localities (constituents expressed as per cent on moisture-free basis)

Depth (ft)	Coarse sand (2·0—0·2 mm.)	Fine sand (0·2—0·02 mm.)	Silt (0·02—0·002 mm.)	Clay (less than 0·002 mm.)	pH
Kanpur (U.P.) *Alluvial loam, unmanured for several years*					
0—1	35·93	26·59	24·09	13·39	8·4
1—2	26·20	25·92	24·58	23·30	8·3
Gorakhpur (U.P.). *Typical loam, well irrigated, yellowish black surface and black subsoil*					
0—1	54·93	14·69	18·24	12·14	6·6
1 2	47·32	18·30	16·97	17·41	7·2
Padrauna (U.P.). *Low land, calcareous, subsoil lighter in colour then the surface*					
0—1	29·66	12·20	44·32	13·82	7·4
1—2	26·83	3·91	52·92	16·34	7·8
Sahjahanpur (U.P.). *Sandy loam, little difference between the surface and the subsoil*					
0—1	50·80	21·98	19·75	7·47	6·6
1—2	38·42	23·85	21·05	16·68	6·7

Methods

Extraction of soluble salts. One hundred grams of soil were treated with 500 c.c. of CO_2-free distilled water and occasionally shaken. The soil suspension was filtered in a Pasteur Chamberland filter after keeping overnight.

Total soluble salts, calcium and magnesium. One hundred c.c. of the extract were taken in a weighed Pt. basin and evaporated to dryness on water bath. It was then dried in an air oven at 105°C. cooled in a desiccator and weighed to a constant weight. The weight of the residue was taken to be the weight of the dissolved salts.

The residue was dissolved in dilute HCl. The solution was then treated with excess of ammonia, reacidified with a few drops of acetic acid to make it just acid and boiled with ammonium oxalate to precipitate calcium. The precipitate of calcium oxalate was washed free from chlorides with hot water, decomposed with dilute H_2SO_4 and the resulting solution titrated with N/10 $KMnO_4$ solution.

The filtrates and the washings were combined and evaporated to dryness and the residue ignited to drive off the ammonium salts. The ignited residue was dissolved in a few c.c. of dilute HCl and the solution was filtered. The filtrate was treated with sodium phosphate and excess of ammonia. After keeping overnight, the

precipitate of magnesium ammonium phosphate was washed with dilute ammonia and then dried in the air. The dry precipitate was dissolved in excess N/10 H_2SO_4 and the excess acid was determined by titration with N/10 NaOH solution with methyl red as indicator [Handy, 1900].

Carbonates, bicarbonates and chlorides. A 100 c.c. aliquot was titrated with N/50 H_2SO_4 with phenolphthalein as indicator. The titre corresponded to carbonates. A few drops of methyl orange were then added to the same aliquot and titration with the standard acid continued till the end point was reached. The difference between the two titres corresponded to bicarbonates.

One c.c. of one per cent K_2CrO_4 solution was then added to the same aliquot and the liquid was then titrated with N/50 $AgNO_3$ solution till the yellow colour of the liquid was changed to faint chocolate. The titre corresponded to chlorides.

Nitrates. Nitrate was estimated by the phenol disulphonic acid method using 20 c.c. of the extract.

Sulphates. Twenty c.c. of the soil extract were treated with one c.c. of a saturated solution of $(NH_4)_2CO_3$ and evaporated to dryness. The residue was treated with hot water and the mixture filtered. The filtrate was treated with five c.c. of a one per cent solution of $BaCrO_4$ in dilute HCl. Excess ammonia was added and the mixture made up to a known volume. The liquid was then filtered and the yellow colour of the filtrate was matched against known standards [Winkler, 1901].

Potassium. A 100 c.c. aliquot was evaporated to dryness and potassium estimated from the residue by the Platinic Chloride method.

Sodium. Sodium was estimated by difference. Acids and bases determined were combined to form salts after the method of combination followed by Leather [1902]. Excess acid was supposed to have been combined with sodium.

*p*H The values of the soils were determined by the colorimetric method.

Mechanical analysis. The mechanical analyses of the soils were carried out by Puri's NaCl dispersion method [Puri, 1929].

Results

The results of estimation of soluble salts in the cultivated soils are given in Table II.

TABLE II

Soluble salts of cultivated soils

(expressed as per cent on moisture-free basis)

Depth (ft)	Total salts	NO_3	CO_3	HCO_3	Cl	SO_4	Ca	Mg	K	Na
Makrera (Ajmere-Merwara)										
0—1	0·0870	..	..	0·0259	0·0106	0·0215	0·0130	0·0023	0·0082	0·0020
1—2	0·0792	..	..	0·0229	0·0106	0·0193	0·0125	0·0018	0·0070	0·0027
Tabiji (Ajmere-Merwara)										
0—1	0·0607	0·0018	..	0·0274	0·0053	0·0066	0·0060	0·0020	0·0007	0059
1—2	0·0615	..	..	0·0244	0·0053	0·0113	0·0060	0·0017	0·0040	0·0046

TABLE II—(*contd.*)

Soluble salts of cultivated soils

(expressed as per cent on moisture-free basis)

Depth (ft)	Total salts	NO	CO_3	HCO_3	Cl	SO_4	Ca	Mg	K	Na
					Jorhat (Assam)					
0—1	0·0789	—	—	0·0183	0·0210	0·0133	0·0100	0·0036	0·0028	0·0055
1—2	0·0731	—	—	0·0183	0·0210	0·0094	0·0130	0·0024	0·0032	0·0034
					Karimganj (Assam)					
0—1	0·1002	—	—	0·0244	0·0315	0·0109	0·0085	0·0024	0·0023	0·0251
1—2	0·0848	—	—	0·0183	0·0245	0·0137	0·0060	0·0024	0·0018	0·0168
					Sylhet (Assam)					
0—1	0·0596	—	—	0·0183	0·1933	0·0021	0·0050	0·0042	0·0014	0·0057
1—2	0·0870	—	—	0·0122	0·0175	0·0283	0·0130	0·0027	0·0032	0·0075
					Chinsurah (Bengal)					
0—1	0·0824	—	—	0·0288	0·0186	0·0112	0·0136	0·0040	0·0030	0·0032
1—2	0·1107	0·0013	—	0·0336	0·0266	0·0123	0·0160	0·0078	0·0031	0·0011
					Rangpur (Bengal)					
0—1	0·0689	—	—	0·0122	0·0243	0·0093	0·0061	0·0038	0·0076	0·0056
1—2	0·0864	—	—	0·0183	0·0213	0·0180	0·0100	0·0048	0·0067	0·0047
					Orai (Bihar)					
0—1	0·0435	—	0·0075	0·0061	0·0035	0·0119	0·0040	0·0029	0·0052	0·0028
1—2	0·1944	0·0006	0·0030	0·0305	0·0709	0·0246	0·0040	0·0033	0·0026	0·0595
					Ranchi (Bihar)					
0—1	0·0599	—	—	0·0107	0·0222	0·0070	0·0030	0·0020	0·0065	0·0106
1—2	0·0440	0·0007	—	0·0197	0·0044	0·0045	0·0040	0·0018	0·0083	—
					Sabour (Bihar)					
0—1	0·1161	—	—	0·0580	0·0071	0·0123	0·0150	0·0041	0·0086	0·0023
1—2	0·0746	—	—	0·0244	0·0089	0·0166	0·0080	0·0024	0·0047	0·0064
					Bijapur (Bombay)					
0—1	0·0765	—	0·0008	0·0397	0·0035	0·0070	0·0140	0·0018	0·0039	—
1—2	0·0566	—	0·0008	0·0271	0·0053	0·0045	0·0100	0·0019	0·0023	—
					Dharwar (Bombay)					
0—1	0·0801	0·0010	—	0·0442	0·0035	0·0047	0·0115	0·0018	0·0047	0·0008
1—2	0·0843	—	—	0·0427	0·0053	0·0082	0·0110	0·0039	0·0058	—

TABLE II—(*contd.*)

Soluble salts of cultivated soils
(expressed as per cent on moisture-free basis)

Depth (ft)	Total salts	NO_3	CO_3	HCO_3	Cl	SO_4	Ca	Mg	K	Na
Kumpta (Bombay)										
0—1	0·0405	—	—	0·0148	0·0044	0·0078	0·0040	0·0025	0·0031	0·0010
1—2	0·0383	—	—	0·0122	0·0053	0·0080	0·0060	0·0030	0·0040	0·0011
Nadiad (Bombay)										
0—1	0·1491	—	0·0030	0·0732	0·0177	0·0055	0·0045	0·0003	0·0051	0·0354
1—2	0·0810	—	0·0015	0·0366	0·0106	0·0053	0·0025	0·0002	0·0074	0·0168
Padegaon (Bombay)										
0—1	0·1028	0·0009	0·0120	0·0427	0·0053	0·0076	0·0015	0·0035	0·0018	0·0232
1—2	0·2427	—	0·0075	0·0732	0·0071	0·0740	0·0030	0·0035	0·0055	0·0678
Sholapur (Bombay)										
0—1	0·0735	0·0013	—	0·0366	0·0027	0·0084	0·0090	0·0033	0·0026	0·0018
1—2	0·0804	0·0015	—	0·0351	0·0053	0·0117	0·0065	0·0020	0·0064	0·0072
Surat (Bombay)										
0—1	0·0564	—	—	0·0275	0·0080	0·0021	0·0060	0·0028	0·0066	..
1—2	0·0666	—	—	0·0336	0·0098	0·0010	0·0080	0·0034	0·0041	0·0016
Akola (M. P.)										
0—1	0·1530	—	—	0·0519	0·0089	0·0422	0·0060	0·0009	0·0021	0·0359
1—2	0·1329	—	0·0015	0·0488	0·0071	0·0312	0·0100	0·0069	0·0019	·0135
Chandkhuri (M. P.)										
0—1	0·1004	—	—	0·0229	0·0071	0·0369	0·0050	0·0030	0·0018	0·0184
1—2	0·0960	—	—	0·0229	0·0079	0·0332	0·0030	0·0036	0·0030	0·0175
Indore (M. P.)										
0—1	0·1101	—	—	0·0336	0·0142	0·0246	0·0050	0·0027	0·0021	0·0226
1—2	0·1050	—	—	0·0275	0·0142	0·0283	0·0110	0·0051	0·0016	0·0088
Kharua (M. P.)										
0—1	0·1112	—	—	0·0397	0·0106	0·0238	0·0020	0·0036	0·0024	0·0227
1—2	0·1148	—	—	0·0366	0·0124	0·0275	0·0170	0·0027	0·0018	0·0093
Kheri (M. P.)										
0—1	0·1107	—	—	0·0229	0·0089	0·0420	0·0080	0·0027	0·0018	0·0181
1—2	0·0914	—	—	0·0259	0·0096	0·0254	0·0070	0·0045	0·0025	0·0134

TABLE II—(*contd.*)

Soluble salts of cultivated soils

(expressed as per cent on moisture-free basis)

Depth (ft)	Total salts	NO_3	CO_3	HCO_3	Cl	SO_4	Ca	Mg	K	Na
					Nagpur (M. P.)					
0—1	0·1191	—	—	0·0397	0·0106	0·0291	0·0150	0·0048	0·0023	0·0080
1—2	0·1167	—	—	0·0366	0·0124	0·0288	0·0110	0·0035	0·0026	0·0148
					Powerkhera (M. P.)					
0—1	0·1154	—	—	0·0305	0·0089	0·0375	0·0120	0·0045	0·0014	0·0117
1—2	0·1048	—	—	0·0366	0·0124	0·0209	0·0130	0·0036	0·0023	0·0089
					Waraseoni (M. P.)					
0—1	0·1170	—	—	0·0305	0·0053	0·0422	0·0080	0·0030	0·0028	0·0186
1—2	0·0800	—	—	0·0183	0·0071	0·0279	0·0070	0·0039	0·0025	0·0079
					Labhandi (M. P.)					
0—1	0·1023	—	—	0·0244	0·0089	0·0349	0·0080	0·0036	0·0028	0·0141
1—2	0·1118	—	—	0·0366	0·0089	0·0287	0·0120	0·0036	0·0033	0·0107
					Aduturai (Madras)					
0—1	0·0966	—	—	0·0244	0·0228	0·0172	0·0060	0·0024	0·0018	0·0197
1—2	0·0882	—	—	0·0275	0·0053	0·0260	0·0060	0·0030	0·0021	0·0123
					Anakapalle (Madras)					
0—1	0·1034	0·0009	—	0·0336	0·0193	0·0152	0·0100	0·0033	0·0049	0·0122
1—2	0·0851	—	—	0·0275	0·0175	0·0117	0·0120	0·0033	0·0035	0·0036
					Coimbatore (Madras)					
0—1	0·0779	—	—	0·0290	0·0061	0·0168	0·0060	0·0042	0·0023	0·0067
1—2	0·1069	0·0009	—	0·0397	0·0121	0·0185	0·0060	0·0030	0·0016	0·0185
					Hagari (Madras)					
0—1	0·0653	—	0·0075	0·0305	0·0105	0·0168	0·0040	0·0024	0·0014	0·0222
1—2	0·1080	—	0·0090	0·0244	0·0195	0·0191	0·0100	0·0021	0·0021	0·0211
					Koilpatti (Madras)					
0—1	0·1068	0·0006	—	0·0183	0·0160	0·0363	0·0080	0·0027	0·0025	0·0188
1—2	0·0944	0·0008	—	0·0168	0·0168	0·0285	0·0070	0·0040	0·0021	0·0135
					Samalkot (Madras)					
0—1	0·1484	—	—	0·0641	0·0088	0·0260	0·0060	0·0027	0·0025	0·0289
1—2	0·1070	—	—	0·0336	0·0123	0·0254	0·0060	0·0033	0·0019	0·0191

TABLE II—(*contd.*)
Soluble salts of cultivated soils
(expressed as per cent on moisture-free basis)

Depth (ft)	Total salts	NO_3	CO_3	HCO_3	Cl	SO_4	Ca	Mg	K	Na
					Taliparamba (Madras)					
0—1	0·0872	—	—	0·0183	0·0177	0·0221	0·0070	0·0063	0·0019	0·0077
1—2	0·0990	0·0008	—	0·0137	0·0158	0·0357	0·0110	0·0030	0·0023	0·0125
					Haripur Hazara (N. W. F. P.)					
0—1	0·1161	—	—	0·0397	0·0213	0·0164	0·0190	0·0051	0·0014	0·0042
1—2	0·1418	0·0005	0·0008	0·0336	0·0190	0·0406	0·0110	0·0051	0·0008	0·0223
					Tarnab (N. W. F. P.)					
0—1	0·4037	—	0·0008	0·0275	0·0239	0·2169	0·0445	0·0067	0·0022	0·0651
1—2	0·3207	0·0007	0·0008	0·0244	0·0452	0·1427	0·0105	0·0026	0·0022	0·0895
					Berhampur (Orissa)					
0—1	0·0896	—	—	0·0366	0·0178	0·0053	0·0045	0·0011	0·0043	0·0204
1—2	0·0911	—	—	0·0183	0·0301	0·0123	0·0040	0·0007	0·0014	0·0254
					Ferozepur (Punjab)					
0—1	0·3111	—	—	0·0397	0·0168	0·1509	0·0490	0·0077	0·0026	0·0294
1—2	0·1048	0·0018	—	0·0366	0·0137	0·0178	0·0155	0·0025	0·0014	0·0081
					Gurdaspur (Punjab)					
0—1	0·0689	—	—	0·0214	0·0204	0·0041	0·0020	0·0080	0·0015	0·0047
1—2	0·0641	—	—	0·0153	0·0204	0·0070	0·0021	0·0053	0·0009	0·0095
					Guzranwala (Punjab)					
0—1	0·0698	—	0·0015	0·0244	0·0106	0·0100	0·0100	0·0033	0·0034	0·0022
1—2	0·0938	—	0·0060	0·0366	0·0080	0·0119	0·0030	0·0017	0·0018	0·0215
					Kalashakaku (Punjab)					
0—1	0·0834	—	0·0180	—	0·0204	0·0171	0·0050	0·0079	0·0023	0·0132
1—2	0·1517	0·0019	0·0315	—	0·0395	0·0279	0·0040	0·0048	—	0·0504
					Kangra (Punjab)					
0—1	0·0603	0·0007	—	0·0183	0·0204	0·0008	0·0105	0·0035	0·0019	0·0007
1—2	0·0542	0·0007	—	0·0153	0·0133	0·0068	0·0095	0·0026	0·0023	0·0007
					Lahore (Punjab)					
0—1	0·0983	0·0009	0·0015	0·0275	0·0106	0·0250	0·0110	0·0043	0·0041	0·0074
1—2	0·0747	0·0006	0·0015	0·0244	0·0089	0·0156	0·0060	0·0024	0·0032	0·0296

TABLE II—(*contd.*)

Soluble salts of cultivated soils

(expressed as per cent on moisture-free basis)

Depth (ft)	Total salts	NO_3	CO_3	HCO_3	Cl	SO_4	Ca	Mg	K	Na
Lyallpur (Punjab)										
0—1	0·0978	0·0009	—	0·0366	0·0195	0·0082	0·0180	0·0026	0·0017	0·0051
1—2	0·0962	0·0008	—	0·0351	0·0177	0·0105	0·0180	0·0029	0·0016	0·0030
Mianwali (Punjab)										
0—1	0·1566	0·0008	0·0015	0·0214	0·0089	0·0718	0·0110	0·0029	0·0051	0·0328
1—2	0·0903	0·0006	0·0015	0·0336	0·0089	0·0158	0·0060	0·0024	0·0032	0·0296
Karachi (Sind)										
0—1	0·2484	0·0055	0·0008	0·0488	0·1029	0·0006	0·0140	0·0190	0·0289	0·0220
1—2	0·4262	0·0015	0·0022	0·0259	0·2535	0·0010	0·0105	0·0096	0·0337	0·1268
Mirpurkhas (Sind)										
0—1	0·1220	—	0·0008	0·0458	0·0169	0·0178	0·0105	0·0044	0·0060	0·0133
1—2	0·1440	—	0·0008	0·0305	0·0222	0·0435	0·0100	0·0037	0·0048	0·0207
Sakrand (Sind)										
0—1	0·6300	0·0638	0·0008	0·0290	0·2624	0·0640	0·1480	0·0232	0·0182	0·0103
1—2	0·5450	0·0459	—	0·0366	0·1988	0·0820	0·1080	0·0145	0·0237	0·0330
Aligarh (U. P.)										
0—1	0·1299	0·0025	—	0·0427	0·0248	0·0166	0·0160	0·0083	0·0014	0·0059
1—2	0·2234	—	—	0·0397	0·0940	0·0152	0·0250	0·0101	0·0013	0·0339
Kanpur (U. P.)										
0—1	0·0639	—	—	0·0275	0·0106	0·0045	0·0050	0·0036	0·0096	0·0012
1—2	0·0710	—	—	0·0336	0·0071	0·0066	0·0065	0·0034	0·0040	0·0043
Gorakhpur (U. P.)										
0—1	0·0771	—	—	0·0305	0·0106	0·0103	0·0085	0·0051	0·0045	0·0007
1—2	0·0962	—	—	0·0460	0·0089	0·0092	0·0105	0·0063	0·0017	0·0025
Padrauna (U. P.)										
0—1	0·1098	0·0015	0·0015	0·0549	0·0071	0·0082	0·0135	0·0066	0·0052	—
1—2	0·0987	0·0005	0·0008	0·0397	0·0166	0·0082	0·0055	0·0045	0·0050	0·0126
Sahjahanpur (U. P.)										
0—1	0·0882	0·0013	—	0·0183	0·0105	0·0287	0·0130	0·0029	0·0015	0·0059
1—2	0·0822	0·0017	—	0·0214	0·0071	0·0247	0·0120	0·0016	0·0008	0·0072

Discussion

It would be observed from the data in Table II, that Kumpta soil contained the minimum total soluble salts both at the surface (0·0405) and at the subsoil (0·0383) and that in Sakrand soil, the salt content was maximum at the surface (0·6300) and the subsoil (0·5450). Though the salt content of the majority of the soils, might not be considered excessive, considerable salinity appeared to exist in Padegaon, Tarnab, Ferozepur and Karachi soils. Nitrates were found to be absent in a large number of the soils studied. In soils where nitrates occurred, they were observed either at the surface or the subsoil or at both. Sakrand soil contained the maximum amount of nitrate at the surface (0·0638) and the subsoil (0·0459). Soluble carbonates were present in some soils ; that from Kalashakaku had the maximum amount of soluble carbonates (surface 0·0180 ; subsoil 0·0315). With the exception of the same soil, bicarbonates in the surface soils varied from 0·0061 (Orai) to 0·0732 (Nadiad) and in the subsoils from 0·0122 (Sylhet and Kumpta) to 0·0732 (Padegaon). Chlorides and sulphates also showed considerable variations. Chlorides of the surface soils varied from 0·0027 (Sholapur) to 0·2624 (Sakrand) and of the subsoils from 0·0044 (Ranchi) to 0·2535 (Karachi). Sulphates of the surface soils varied from 0·0006 (Karachi) to 0·2169 (Tarnab) and of the subsoils from 0·0010 (Surat) to 0·1427 (Tarnab). The minimum calcium content was observed in Gurdaspur soil (surface 0·0020 ; subsoil 0·0021) and the maximum at Sakrand (surface 0·1480 ; subsoil 0·1080). The minimum magnesium content was noticed at the surface (0·0003) and at the subsoil (0·0002) of Nadiad soil and maximum at the surface (0·0232) and the subsoil (0·0145) in the Sakrand soil. Soluble potassium varied from 0·0007 (Tabiji) to 0·0289 (Karachi) at the surface and from 0·0017 (Aligarh) to 0·0337 (Karachi) at the subsoil. Sodium contents of the surface soils from Surat, Padegaon and Bijapur and of the subsoils from Ranchi, Dharwar and Bijapur were negligible and could not be measured while maximum sodium content of the surface soil (0·0651) was observed at Tarnab and of the subsoil (0·1268) at Karachi.

A comparison of the total salt contents of virgin and cropped soils showed that in majority of cases the latter contained more soluble matter than the former in both the top first foot and the layer next below (Table III). It was clear, therefore, that soluble salts in cultivated soils, occurred in larger amounts than that absorbed by the plants or lost through drainage. The nature of crops had, obviously a great influence on the equilibrium conditions of these processes and that was why, in some cases, the salt content was higher in some cultivated soils than in others.

The soils that showed greater salt contents in the virgin than in the cultivated state were from Hagari, Samalkot and Koilpatti in Madras, Makrera and Tabiji in Ajmere-Merwara, Kangra and Gurdaspur in the Punjab and Ranchi in Bihar. It might also be observed that though in virgin soils, the salt contents rarely exceeded 0·2 per cent, some of the cultivated soils contained much higher amount of soluble salts. In Sakrand soil, the major soluble constituents being calcium salts, the high salt content was not very unfavourable, but in the soil from Hagari, the salts of calcium, as compared with those of sodium were low with the result that the saline condition was not very satisfactory for healthy crop growth.

TABLE III

Soluble salt contents of virgin and cultivated soils

(constituents expressed as per cent on moisture-free basis)

Soil	Depth (ft)	Virgin	Cultivated
Makrera (Ajmere Merwara)	0—1	0·0800	0·0870
	1—2	0·1190	0·0792
Tabiji (Ajmere Merwara)	0—1	0·0680	0·0607
	1—2	0·1280	0·0615
Jorhat (Assam)	0—1	0·0710	0·0789
	1—2	0·0500	0·0731
Karimgunj (Assam)	0—1	0·0650	0·1002
	1—2	0·0700	0·0848
Sylhet (Assam)	0—1	0·0390	0·0596
	1—2	0·0360	0·0870
Chinsurah (Bengal)	0—1	0·0510	0·0824
	1—2	0·600	0·1107
Rangpur (Bengal)	0—1	0·0460	0·0689
	1—2	0·0370	0·0867
Ranchi (Bihar)	0—1	0·0930	0·0599
	1—2	0·0160	0·0440
Padegaon (Bombay)	0—1	0·0950	0·1028
	1—2	0·0950	0·2427
Surat (Bombay)	0—1	0·0430	0·0564
	1—2	0·0420	0·0666
Akola (M. P.)	0—1	0·0530	0·1530
	1—2	0·0580	0·1329
Chandkhuri (M. P.)	0—1	0·0200	0·1004
	1—2	0·0250	0·0960

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TABLE III—(*contd*).

Soluble salt contents of virgin and cultivated soils
(constituents expressed as per cent on moisture-free basis)

Soil	Depth (ft.)	Virgin	Cultivated
Indore (M. P.)	0—1	0·0550	0·1101
	1—2	0·0400	0·1050
Kharua (M. P.)	0—1	0·0630	0·1112
	1—2	0·0480	0·1148
Kheri (M. P.)	0—1	0·0430	0·1107
	1—2	0·0400	0·0914
Nagpur (M. P.)	0—1	0·0700	0·1191
	1—2	0·0500	0·1167
Powerkhera (M. P.)	0—1	0·0440	0·1154
	1—2	0·0390	0·1048
Waraseoni (M. P.)	0—1	0·0680	0·1170
	1—2	0·0230	0·0800
Anakapalle (Madras)	0—1	0·0400	0·1034
	1—2	0·0400	0·0851
Coimbatore (Madras)	0—1	0·0350	0·0779
	1—2	0·0330	0·1069
Hagari (Madras)	0—1	0·1350	0·0653
	1—2	0·3330	0·1080
Koilpatti (Madras)	0—1	0·0930	0·1068
	1—2	0·1650	0·0944
Samalkot (Madras)	0—1	0·1100	0·1484
	1—2	0·1750	0·1070
Taliparamba (Madras)	0—1	0·0700	0·0872
	1—2	0·0600	0·0990
Haripur Hazara (N. W. F. P.)	0—1	0·0880	0·1161
	1—2	0·0780	0·1418

TABLE III—(*contd.*)

Soluble salt contents of virgin and cultivated soils

(*constituents expressed as per cent on moisture-free basis*)

Soil	Depth (ft.)	Virgin	Cultivated
Tarnab (N. W. F. P.)	0—1	0·1750	0·4037
	1—2	0·1450	0·3207
Berhampur (Orissa)	0—1	0·0350	0·0896
	1—2	0·0350	0·0911
Gurdaspur (Punjab)	0—1	0·0840	0·0689
	1—2	0·0840	0·0641
Kangra (Punjab)	0—1	0·0720	0·0603
	1—2	0·1060	0·0542
Lahore (Punjab)	0—1	0·0580	0·0983
	1—2	0·1150	0·0747
Lyallpur (Punjab)	0—1	0·0600	0·0978
	1—2	0·1050	0·0962
Mianwali (Punjab)	0—1	0·0900	0·1566
	1—2	0·0500	0·0903
Karachi (Sind)	0—1	0·3200	0·2484
	1—2	0·1900	0·4262
Sakrand (Sind)	0—1	0·1290	0·6300
	1—2	0·0840	0·5450
Padrauna (U. P.)	0—1	0·0910	0·1098
	1—2	0·0300	0·0987
Sahjahanpur (U. P.)	0—1	0·0250	0·0882
	1—2	0·0200	0·0822

From the observations made so far, it was clear that the depletion of soluble salts from the soils by crop growth was not so acute in Indian soils. Rather, in some cases, there might be actual accumulation of soluble salts giving rise to salinity and alkalinity as had been observed in the cultivated fields at Pusa by Desai and Sen [1953] and at Karnal by Sen [1953]. Subjected to extremes of climate, under

tropical and subtropical conditions and aided by cultural operations, Indian cultivated soils might be developing soluble salts in sufficient amounts making good or exceeding the loss from removal in crops and drainage. There might be relative diminution in the proportion of one particular saline constituent over another as a result of unequal absorption by crop plants, but there seemed to be sufficient reserves of saline nutrients for subsequent crops.

Summary and conclusions

Total soluble salts and individual soluble constituents of 52 cultivated soils and their subsoils from different parts of India were estimated.

Total salt contents and the individual soluble constituents of the soils showed considerable variations. Total soluble salt contents of the surface soils varied from 0·0405 to 0·6300 per cent while those of subsoils varied from 0·0383 to 0·5450 per cent. Though the salt contents of the majority of the soils might not be considered excessive, there were some soils like Padegaon, Tarnab, Ferozepur and Karachi where considerable salinity appeared to exist.

A comparison of the soluble salt contents of the cultivated soils with those of the virgin soils in the adjoining areas showed that the cultivated soils, in most cases, contained more soluble salts than the virgin soils.

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STUDIES ON THE DIASTATIC ACTIVITY OF CERTAIN INDIAN WHEATS

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(With one text-figure)

Diastatic enzymes of wheat flour play important roles in panary fermentation. The two main components of this group of enzymes are α-amylase which produces dextrin and β-amylase which converts starch into maltose. The sound ungerminated wheat contains chiefly β-amylase ; α-amylase being not present in appreciable quantity in active form. The latter, however, appears in significant amount during germination.

In panary fermentation yeast is primarily responsible for the production of carbon dioxide and alcohol by fermenting the sugar present in the dough. The carbon dioxide thus produced, distends the dough while alcohol is driven off at the time of baking. The making of good-sized loaves, therefore, requires that an ample supply of gas should be produced during the fermentation and specially at the end, and that a sufficient quantity of this gas is retained within the dough. The sugar, responsible for the production of this gas is formed from the flour by the action of β-amylase present therein. It is, therefore, necessary that a flour should have sufficient diastatic activity to ensure adequate gas production and a certain amount of proteolytic activity to retain the evolved gas.

In view of these facts, diastatic activity of certain varieties of Indian wheat has been studied and reported here.

Experimental

Samples. The samples of different varieties of wheat were stored in stoppered amber-coloured bottles in the cold. The grains were thoroughly ground in hand-driven laboratory mills and passed through a 40-mesh sieve. The flours thus obtained were found to have been extracted to the extent of 70 to 75 per cent in most of the samples. Freshly ground samples were used for all estimations.

The method described by Blish and Sandstedt [1933] based on the reduction of alkaline ferricyanide has been followed and the results are presented as ' maltose figures '. Blank determinations for the amount of reducing sugars originally present in the flour have also been carried out. All the estimations were done at least in duplicate. Protein (nitrogen $\times 5{\cdot}7$) was estimated according to the usual Kjeldahl method. Gluten was estimated by the kneading method as described in A.O.A.C. [1940].

Maltose figures of 30 samples of different varieties of wheat along with the percentage extraction and protein contents are given in Table I. The gluten contents of 20 samples are also included in it.

TABLE I

Protein, gluten, and maltose figures of wheat
(on oven dry basis)

Variety of wheat	Percentage of extraction	Protein per cent (N×5·7)	Gluten per cent	Total maltose (mg./10 gm. of flour)	Blank*	Maltose figure (mg./10 gm. of flour)
NP 4	76·6	13·7	10·1	245·2	35·2	210·0
NP 704	70·0	9·9	6·8	232·8	38·4	194·4
NP 709	76·7	9·2	6·9	205·0	35·9	169·1
NP 710	72·1	11·7	9·1	250·4	35·4	215·0
NP 715	75·0	13·3	10·8	215·7	32·5	183·2
NP 717	70·0	13·3	..	213·0	40·8	172·2
NP 718	77·0	14·9	11·4	214·0	32·6	181·4
NP 720	76·0	11·7	8·9	237·2	28·2	209·0
NP 721	76·5	12·0	9·1	223·9	40·9	183·0
NP 723	70·8	15·0	11·7	189·1	43·9	145·2
NP 733	70·0	12·7	9·7	186·5	34·7	151·8
NP 737	75·7	10·9	7·6	208·2	40·9	167·3
NP 745	68·7	13·6	11·2	166·3	42·2	124·1
NP 755	72·0	10·1	..	192·9	42·1	150·8
NP 758	74·2	9·9	7·4	204·0	35·7	168·3
NP 760	72·6	10·7	8·4	239·3	42·6	196·7
NP 761	73·3	12·0	10·3	193·9	43·9	150·0
NP 762	70·2	8·7	5·9	259·8	42·9	216·9
NP 764	70·2	9·2	6·6	240·4	41·6	198·8
NP 768	74·0	10·0	..	220·0	42·4	177·6
NP 770	72·0	10·2	..	195·5	38·7	156·8
NP 771	70·0	12·9	..	220·0	46·0	174·0
NP 779	71·0	9·8	7·0	259·5	42·5	217·0
NP 12	73·3	13·3	..	177·0	40·3	136·7
NP 165	73·0	10·7	7·5	188·5	35·7	152·8
NP 111	71·5	10·2	7·1	191·2	33·5	157·7
NP 52	72·0	10·8	..	185·0	32·9	152·1
Pb. C. 518	70·0	10·0	..	191·3	38·4	152·9
Pb. C 591	70·0	9·7	..	228·3	42·7	185·6
C 13	67·0	10·1	..	239·6	48·8	190·8

*Blank determination for th e original reducing sugar

DISCUSSION

The maltose figures of most of the varieties of Indian wheat reported here lie within the range of 150 to 230. If the maltose figure is below 150, there is reported to be a danger that the dough may produce insufficient gas ; if on the other hand, the maltose figure is much above 230, the crump may be dump and sticky and the loaf may show signs of collapse [Kent-Jones and Amos, 1947]. The maltose figures of NP 779, 762, 710, 4 and 720 appear to be fairly high in comparison with those of the others.

It may be noted that according to Blish, *et al.* [1938], β-amylase is capable of acting on the available starch alone, that is, granules which have been ruptured or

damaged during the milling process. Its action ceases when about 60 per cent of the total available starch is converted into maltose. The greater the concentration of β-amylase in the flour, the more quickly will the 60 per cent conversion level be reached. It has, however, no significant action on raw starch. Normally the available starch represents 7 to 13 per cent of the total starch [Schultz, Atkin and Frey, 1939]. The maltose value or maltose figure represents, therefore, about 60 per cent conversion of the available starch fraction.

It is important to note that injury to the starch resulting from the overgrinding of the flour leads to increased diastatic activity and as such commercially milled flours show higher diastatic activities than flours ground on a small experimental mill from the same wheats respectively, mainly due to more severe grinding of starch particles in the commercial process [Blish, *et al.*, 1938 ; Alsberg and Griffin, 1925 ; Pascoe, *et al.*, 1930]. Similar results have also been found by us and therefore for the sake of comparison all samples of wheat studied by us, were ground under the same conditions and were passed through a sieve of 40-mesh per linear inch. The figures reported here may, therefore, be not identical with or may be somewhat less than those obtained from the same wheats milled commercially. Reducing sugars originally present in the wheat samples were found by us to vary from 28·2 to 48·8 which is in agreement with the observations of Dadswell and Gardner [1947] who reported figures ranging from 24 to 47.

There appears to be no well-defined relationship between protein content and the diastatic activity of wheaten flours. While Dadswell and Wragge [1940] are of the opinion that the protein content of the flours examined bears no correlation to the proportion of injured starch granules or the maltose figure ; Walden and Larmour [1948] expressed the view that the autolytic maltose values of flour clearly reveal the inverse relationship with the protein contents. The figures obtained by us, shown graphically (Fig. 1, page 48) support neither of the two propositions. But it will be quite apparent from the figures that in a tolerably good number of cases protein content varies inversely with the maltose figure, though there are quite a number of exceptions also. The gluten content has been found to be approximately proportional to the protein content and hence the relationship of diastatic activity to gluten or protein content is the same.

Summary

1. Thirty varieties of Indian wheat have been studied for their diastatic activity, most of which lie within the range of 150 to 230.

2. The diastatic activity of NP 779, 762, 710, 4 and 720 appears to be fairly high, ranging from 217 to 209.

3. The diastatic activity of wheaten flour does not seem to have any well-defined relationship with the protein or gluten content though there is a tendency to be inversely proportional.

Acknowledgment

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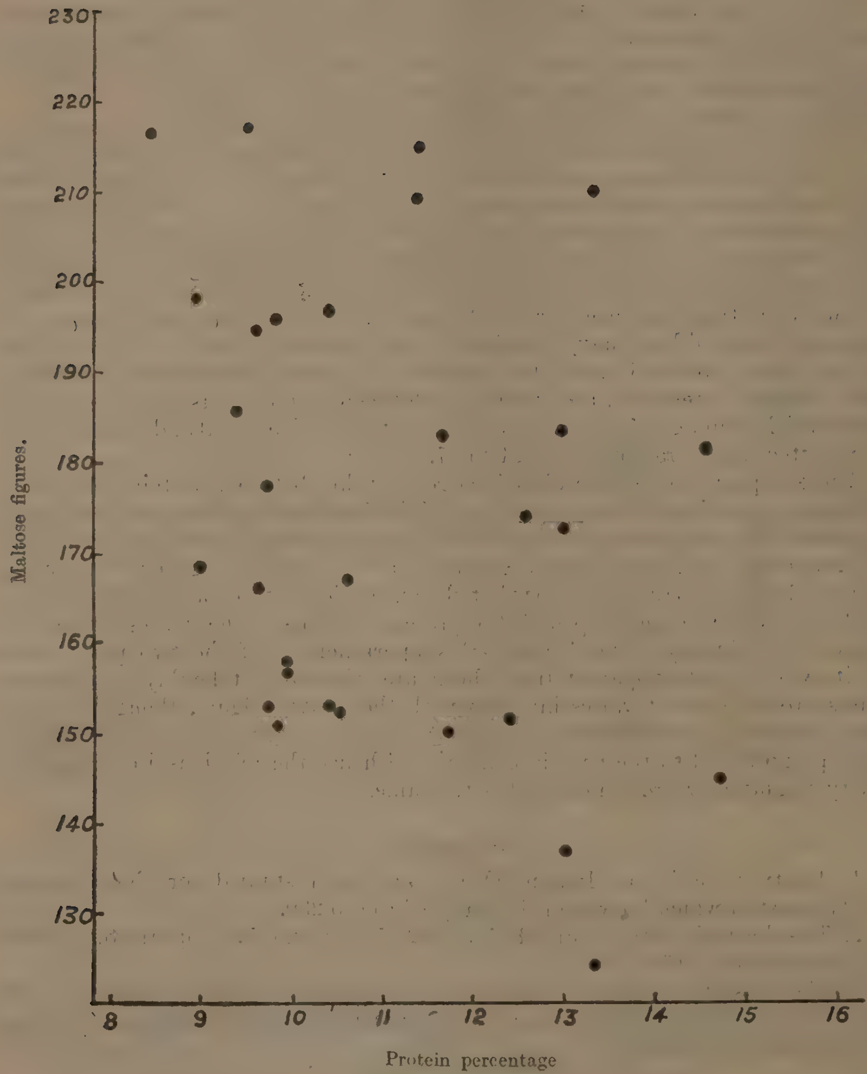

FIG. 1. Diastatic activity of certain Indian wheats

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ACTION OF TANK SILTS ON SOILS-II

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In an earlier communication, results of experiments dealing with nitrification of tank silts in Delhi soil were detailed. It was shown that in a light and slightly alkaline soil like Delhi, the formation of nitrates was as rapid as in the case of oil cakes; in addition, there was a good deal of evidence of considerable fixation of nitrogen [Sen and Asija, 1953]. The fixation of nitrogen was suggested to account for prolonged residual manurial effects from application of tank silts.

It was, however, not known if the same rate of nitrification would also be observed if tank silts were incorporated with a soil with high amounts of clay where aeration was necessarily more restricted than in loams and sandy loams or with an acid soil where nitrification was generally believed to be limited or inhibited by unfavourable conditions of soil reaction. It was well known that, under similar conditions, sandy soils showed nitrification more easily than heavy clay soils where conditions of aeration were not very favourable [Waksman and Starkey, 1947]. In the case of acid soils, it was also known that nitrification could not be very active due to the optimum reaction for the nitrosomonas and the nitrobacter being on the alkaline side [Corbet, 1935] and as had been shown by Biswas, Singh and Joshi [1946].

The present report deals with observations from results of nitrification experiments with tank silts when they were incorporated with a soil with high clay content from Madras (Guntur) and an acid soil from Assam (Jorhat).

Materials and methods

During the nitrification studies with Guntur soil, silts from the following villages in West Bengal were used :

Village	District
Aurangabad	Murshidabad
Kalyanpur	24-Parganas
Kulpi	24-Parganas
Maldah	Maldah
Noada	Murshidabad
Sirshia	Birbhum
Suri	Birbhum

With Jorhat soil, the same tank silts were used with the exception of one from Sirshia which was exhausted. This was replaced by a sample of tank silt from Rajnagar, District Midnapur.

Composition of the soils from Guntur and Jorhat and of the tank silts is given in the Appendices I and II respectively.

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Methods

The soils (1 foot depth) were sampled through a 2 mm. sieve and mixed with sufficient tank silt to supply about 30 mg. of nitrogen per 100 gm. of soil. Sufficient water was added to the soil silt mixtures to make the moisture content equal to one-third their saturation capacities. This moisture content was maintained throughout the period of the experiments. Losses of moisture were made up by addition of water at intervals of two weeks when nitrite, nitrate, organic and ammoniacal nitrogen, organic carbon, pH and salinity were determined. It was observed that in some soil silt mixtures thread-like plants developed after 24 hours of moistening to one-third their saturation capacities. These were removed as it was thought probable that the growth of the plants might interfere with subsequent changes in the silt-treated soils which were analysed again for the constituents quoted. The data quoted as original composition of the soils, therefore, referred to the composition after 24 hours. The experiments were discontinued after a period of eight weeks.

The analytical methods followed were similar to ones detailed in an earlier communication [Sen and Asija, *loc. cit.*].

Results

Guntur soil

In Table I are given the average contents of organic, ammoniacal, nitrite and nitrate nitrogen in Guntur soil, with and without the treatment with different silts, at different periods.

It would be observed that with the exception of soil treated with silt from Maldah, there was a good deal of formation of nitrates in all the cases during eight weeks. Though the amounts of nitrates formed were not similar in all the cases, the soils showed increases also in total nitrogen at the end of eight weeks, showing fixation of nitrogen.

TABLE I

Average nitrogen contents of Guntur soil with and without treatment with tank silts during different periods

(*mg. per cent*)

Contents	Different pe,iods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
			Soil without silt		
Org. N	70·00	68·59	70·65	68·52	68·14
NH_4 N	2·90	2·39	2·25	2·20	2·34
NO_2 N	*tr*	0·08	0·10	0·27	0·32
NO_3 N	*tr*	0·23	0·25	1·24	2·45
Total	72·90	71·29	73·25	72·23	73·25

TABLE I—(*contd.*)

Average nitrogen contents of Guntur soil with and without treatment with tank silts during different periods

(*mg. per cent*)

Contents	Different periods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
Soil treated with silt from Aurangabad					
Org. N	85·21	96·58	88·63	108·50	112·47
NH_4 N	19·78	23·11	24·64	21·93	15·68
NO_2 N	0·03	0·65	0·79	2·07	1·03
NO_3 N	0·19	0·32	2·64	7·83	12·94
Total	105·21	120·66	112·73	140·33	142·12
Soil treated with silt from Kalyanpur					
Org. N	104·60	96·36	91·16	99·26	97·50
NH_4 N	20·75	24·71	31·86	21·20	15·83
NO_2 N	0·04	0·61	0·68	2·06	1·06
NO_3 N	0·14	0·71	2·44	7·27	16·07
Total	125·53	122·39	126·14	129·79	130·46
Soil treated with silt from Kulpi					
Org. N	91·54	94·99	103·70	103·30	100·80
NH_4 N	18·33	26·66	27·47	10·40	11·66
NO_2 N	0·06	0·45	0·78	1·14	0·96
NO_3 N	0·19	0·48	1·14	17·58	26·19
Total	110·12	122·58	123·09	133·40	139·61
Soil treated with silt from Maldah					
Org. N	105·00	85·92	105·60	106·32	121·20
NH_4 N	20·99	21·66	21·34	25·45	26·74
NO_2 N	0·08	0·68	0·73	2·13	1·06
NO_3 N	0·13	0·71	1·05	1·94	1·35
Total	126·20	108·97	128·72	135·84	150·35

TABLE I—(*contd.*)

Average nitrogen contents of Guntur soil with and without treatment with tank silts during different periods

(*mg. per cent*)

Contents	Different periods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
Soil treated with silt from Noada					
Org. N	113·40	102·10	100·80	101·50	107·30
NH_4 N	13·29	23·25	23·51	25·92	11·73
NO_2 N	0·03	0·65	0·84	2·20	1·26
NO_3 N	0·19	0·65	5·56	16·04	26·34
Total	126·91	126·65	130·71	145·66	146·63
Soil treated with silt from Sirshia					
Org. N	108·80	96·92	81·04	86·66	96·65
NH_4 N	17·05	29·82	22·86	23·61	34·17
NO_2 N	0·03	0·34	0·84	2·15	1·04
NO_3 N	0·19	0·21	1·05	1·81	3·57
Total	126·07	127·29	105·79	114·23	140·43
Soil treated with silt from Suri					
Org. N	102·30	100·00	104·50	108·70	110·60
NH_4 N	19·85	20·56	25·45	21·08	21·79
NO_2 N	0·04	0·36	0·73	2·42	1·07
NO_3 N	0·16	0·29	0·94	3·01	5·99
Total	122·35	126·21	131·62	135·21	139·55

Average contents of organic carbon, soluble salts and *p*H values of the Guntur soil with and without the treatment with tank silts, during different periods are given in Table II.

In most cases, organic carbon contents of the silt-treated soil decreased but these decreases were not very high ; there was even a slight increase in the case of soil mixed with silt from Aurangabad. Variations in salinities of the soil silt mixtures were not very singular ; in some cases, there was increase in salinity and sometimes there was decrease as a result of nitrification. There was no remarkable change in the reactions of the soil silt mixtures at any time during nitrification.

TABLE II

Average contents of organic carbon, soluble salts and pH values of Guntur soil with and without treatment with tank silts at different periods

(mg. per cent)

Contents	Different periods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
	Soil without silt				
Organic carbon	368·2	362·8	364·2	351·5	363·5
Soluble salts	154·0	164·7	182·8	172·9	190·6
*p*H	7·5	7·4	7·5	7·4	7·4
	Soil treated with silt from Aurangabad				
Organic carbon	467·8	471·5	508·3	507·6	486·1
Soluble salts	167·4	218·4	216·6	242·2	232·3
*p*H	7·5	7·8	7·4	7·4	7·6
	Soil treated with silt from Kalyanpur				
Organic carbon	495·5	435·0	501·9	472·3	485·7
Soluble salts	191·8	217·7	172·0	180·4	198·7
*p*H	7·6	8·0	7·7	7·4	7·4
	Soil treated with silt from Kulpi				
Organic carbon	470·8	445·7	462·7	457·4	418·9
Soluble salts	195·1	232·8	328·8	287·8	233·3
*p*H	7·6	7·5	7·5	7·2	7·3
	Soil treated with silt from Maldah				
Organic carbon	515·3	460·2	499·9	467·3	452·7
Soluble salts	165·3	185·7	157·6	167·9	161·7
*p*H	7·6	7·6	7·6	7·3	7·6

TABLE II—(*contd.*)

Average contents of organic carbon, soluble salts and pH values of Guntur soil with and without treatment with tank silts at different periods

(*mg. per cent*)

Contents	Different periods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
	Soil treated with silt from Noada				
Organic carbon	508·3	460·5	513·0	494·9	467·8
Soluble salts	179·4	255·8	227·5	314·8	268·8
*p*H	7·6	7·7	7·5	7·4	7·4
	Soil treated with silt from Sirshia				
Organic carbon	467·4	457·4	518·3	467·0	463·8
Soluble salts	255·0	285·8	173·6	179·6	138·1
*p*H	7·4	7·6	7·6	7·4	7·4
	Soil treated with silt from Suri				
Organic carbon	520·5	449·6	504·7	473·2	431·6
Soluble salts	179·9	204·5	245·0	189·2	144·3
*p*H	7·4	7·6	7·5	7·6	7·5

Jorhat soil

In Jorhat soil, there were appreciable increases in organic and total nitrogen, as a result of treatment with different tank silts, at the end of eight weeks (Table III). Contrary to ordinary expectations, there was a good deal of nitrification in the case of the soil mixed with silts from Kulpi, Noada and Suri. Nitrification was noticeable in the soil when treated with silts from Aurangabad and Kalyanpur. Silts from Maldah and Rajnagar failed to nitrify to any measurable extent even after a period of eight weeks.

TABLE III

Average nitrogen contents of Jorhat soil with and without treatment with tank silts during different periods

(*mg. per cent*)

Contents	Different pericds				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
	Soil without silt				
Org. N	73·04	69·86	72·49	79·91	78·23
NH_4 N	8·33	10·76	13·92	14·49	13·98
NO_2 N	..	..	..	..	*tr*
NO_3 N	..	..	..	..	..
Total	81·37	80·62	86·41	94·40	92·21

TABLE III—(*contd.*)

Average nitrogen contents of Jorhat soil with and without treatment with tank silts during different periods

(*mg. per cent*)

Contents	Different periods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
Soil treated with silt from Aurangabad					
Org. N	88·65	88·79	97·30	96·84	99·64
NH_4 N	25·11	26·49	19·67	19·46	17·77
NO_2 N	0·06	0·85	..	..	..
NO_3 N	..	·27	0·60	0·70	1·69
Total	113·82	116·40	117·57	117·00	119·10
Soil treated with silt from Kalyanpur					
Org. N	89·80	87·66	85·80	80·60	92·60
NH_4 N	20·69	29·89	33·65	37·91	27·97
NO_2 N	0·06	0·36	0·57	0·79	0·93
NO_3 N	..	·72	4·30	4·53	4·81
Total	110·55	118·63	124·32	123·83	126·31
Soil treated with silt from Kulpi					
Org. N	71·03	72·45	74·60	73·37	77·69
NH_4 N	14·16	18·56	11·54	17·75	15·76
NO_2 N	0·10	0·32	0·25	0·25	0·28
NO_3 N	..	6·01	8·79	8·99	8·80
Total	85·29	97·34	95·18	100·36	102·53
Soil treated with silt from Maldah					
Org. N	82·57	81·10	84·08	91·07	93·90
NH_4 N	23·15	25·69	22·58	17·35	19·89
NO_2 N	0·90	0·05	..	..	..
NO_3 N	..	..	*tr*	*tr*	*tr*
Total	105·81	106·84	106·66	108·42	113·79

TABLE III—(*contd.*)

Average nitrogen contents of Jorhat soil with and without treatment with tank silts during different periods

(*mg. per cent*)

Contents	Original	2 weeks	4 weeks	6 weeks	8 weeks
	Different periods				
Soil treated with silt from Noada					
Org. N	83·70	89·23	85·50	92·90	99·26
NH_4 N	21·33	22·32	14·30	12·86	11·85
NO_2 N	0·06	0·85	0·54	0·47	0·31
NO_3 N	..	6·27	13·44	12·97	12·18
Total	105·16	118·67	113·78	118·20	123·60
Soil treated with silt from Rajnagar					
Org. N	65·45	75·94	78·58	84·34	85·43
NH_4 N	12·21	14·43	21·07	19·11	17·97
NO_2 N	0·07	0·36	..	..	..
NO_3 N	..	..	*tr*	*tr*	*tr*
Total	81·73	90·73	99·65	103·45	103·40
Soil treated with silt from Suri					
Org. N	66·89	81·52	81·50	92·50	95·45
NH_4 N	14·00	14·47	16·92	15·30	10·34
NO_2 N	0·06	0·94	0·57	0·57	0·38
NO_3 N	..	4·75	11·54	10·65	12·15
Total	80·95	101·68	110·53	109·02	118·32

Average contents of organic carbon and soluble salts and pH values of the Jorhat soil with and without treatment with tank silts during different periods are given in Table IV.

TABLE IV

Average contents of organic carbon and soluble salts and pH values of Jorhat soil with and without treatment with different tank silts and different periods

(mg. per cent)

Contents	Different periods				
	Original	2 weeks	4 weeks	6 weeks	8 weeks
Soil without silt					
Organic carbon	424·2	420·1	425·6	423·7	434·5
Soluble salts	68·7	69·5	68·6	71·4	72·3
*p*H	5·6	5·8	5·7	5·6	5·9
Soil treated with silt from Aurangabad					
Organic carbon	403·6	428·1	459·8	431·4	442·6
Soluble salts	82·9	81·1	83·8	88·6	87·1
*p*H	6·5	6·7	6·4	6·3	6·4
Soil treated with silt from Kalyanpur					
Organic carbon	388·1	398·5	459·5	407·5	405·8
Soluble salts	75·8	74·8	77·4	82·6	86·8
*p*H	6·7	6·8	6·8	6·6	6·7
Soil treated with silt from Kulpi					
Organic carbon	403·6	405·8	384·5	393·7	346·9
Soluble salts	125·6	118·4	114·8	120·2	117·6
*p*H	7·0	7·1	6·9	6·8	7·0
Soil treated with silt from Maldah					
Organic carbon	386·9	398·0	443·1	412·7	419·3
Soluble salts	120·0	118·0	118·2	120·4	121·1
*p*H	6·2	6·5	6·4	6·2	6·2
Soil treated with silt from Noada					
Organic carbon	408·1	386·8	470·5	420·7	448·0
Soluble salts	78·4	67·0	72·0	83·6	78·3
*p*H	7·0	7·1	7·1	7·1	7·1
Soil treated with silt from Rajnagar					
Organic carbon	394·9	411·0	478·2	442·9	402·5
Soluble salts	95·0	93·0	92·2	95·1	93·7
*p*H	6·4	6·5	6·3	6·2	6·2
Soil treated with silt from Suri					
Organic carbon	410·2	390·9	479·2	414·2	436·7
Soluble salts	85·7	91·6	91·8	84·7	88·2
*p*H	6·9	7·0	6·9	6·7	6·9

With the exception of the soil mixed with silt from Kulpi, there were increases in organic carbon in all the soil silt mixtures after a period of eight weeks. Though the *p*H value of the soil was 5·4, it came above 6·0 in all the mixtures as a result of incorporation of tank silts with the soil. After a period of two weeks, there were slight increases in *p*H in all the cases. The *p*H values of the mixtures otherwise remained more or less the same during the different periods of observations.

Discussion of results

It was observed earlier, that in a light and slightly alkaline soil like Delhi, the tank silts showed appreciable formation of nitrates and also that, at no stage, the amounts of nitrites formed were significant. In a clayey soil like Guntur (Table I), nitrates formed during a period of eight weeks were, in certain cases, higher than those formed in Delhi soil. There was also formation of appreciable amounts of nitrites, particularly at the end of six weeks. Probably the difference in the nature of organic matter in silts as reflected in the rate of nitrification which was not apparent under conditions of free aeration in sandy soils, was exhibited under conditions of restricted aeration in a heavy soil like Guntur. Even in a sandy but appreciable acid soil like Jorhat (Table III), nitrification was quite active above a *p*H 6·5.

Even at a *p*H 6·5, measurable quantities of nitrates were formed within a period of eight weeks in Jorhat soil. With *p*H values of the soil silt mixtures between 6·2 and 6·4, only traces of nitrates were formed and nitrites were absent. At *p*H values between 6·9 and 7·0, nitrates formed within a period of eight weeks were even higher than those formed in Delhi soil. This was probably due to more open nature of the Jorhat soil. The rate of nitrification was, therefore, dependent upon the *p*H value attained by the soil. This had also been observed by earlier workers [Walton, 1928 ; Joshi and Biswas, 1948]. A rise in *p*H value of the acid soil was observed to be effected by incorporation of tank silts with it. Liming of an acid soil, therefore, might not be necessary when silts were applied to it unless the *p*H value of the soil was less than 5·5.

Increase in the total nitrogen content of the silt-treated soils had been observed in the case of all the silts and all the soils—Delhi, Guntur and Jorhat. This was a definite evidence of nitrogen fixation and this was independent of the nature of the soil and was probably a characteristic of the tank silts themselves. In the case of Delhi and Guntur soils (Table II), the fixation in part might be due to Azotobacter. There was some loss of organic carbon in these soils. From the losses of organic carbon in these soils, it seemed however, that it was hardly possible that Azotobacter alone could account for it and it was surmised that nitrogen fixing blue green algae were responsible for a large part of the fixation. In the case of the Jorhat soil, carbon contents in most cases had increased (Table IV) and it was probable that nitrogen fixing algae played a greater part in this fixation process.

With progressive nitrification, progressive increases in salinity were observed in the case of the Delhi soil incorporated with different tank silts. In the case of Guntur soil, the soil silt mixtures that showed appreciable nitrification increased in salinity ; in other silt-treated soils the salinities either decreased or remained

more or less the same. In the case of the acid soil from Jorhat, the salinities of the soil silt mixtures did not show such variations even in the cases when fair quantities of nitrates developed. Restrictions put to the increases in salinity might have been due to the requirements of the microbiological population including the algae whose nature must be different from those in alkaline soils like Delhi or Guntur and which remained yet to be investigated. Increases in salinity or decreases in organic carbon of Guntur and Jorhat soils kept under similar conditions without application of silts as controls during the period under observation were negligible.

In both Guntur and Jorhat soils, there were increases in *p*H during the first two weeks accompanied by increases in ammoniacal nitrogen like Delhi soil. The *p*H values of the soil silt mixtures varied somewhat irregularly tending at the end of eight weeks to return to the *p*H values of the mixtures at the beginning of the experiment. Most of the tank silts used during the investigation being acidic, they tended to decrease the *p*H values of the soil with reactions on the alkaline side when incorporated with them. In spite of their being acidic in nature, they increased the *p*H value of an acid soil like Jorhat. The changes in the *p*H values of the soils effected by the incorporation of tank silts with them did not change materially at least during a period of eight weeks during which the present studies were conducted.

Summary and conclusions

In an earlier communication, results of investigations on nitrification of tank silts in Delhi soil were reported. It was shown that nitrification in such soil was quite active ; in addition there was some evidence of fixation of nitrogen in all the soil silt mixtures.

The present is a report of the results of similar studies made in a heavy clay soil from Guntur and in an acid soil from Jorhat.

In Guntur soil, tank silts nitrified at different rates, quite unlike Delhi soil where the rate of nitrification of tank silts was more or less uniform. The amounts of nitrates formed in Guntur soil, during a period of eight weeks, were higher with certain silts than what formed in Delhi soil under similar conditions. In other cases, they were lower than the amounts of nitrates formed in Delhi soil under similar conditions. Nitrification in Guntur soil was also characterised by formation of appreciable quantities of nitrites at the end of six weeks.

In Jorhat soil, there was a good deal of formation of nitrates with certain silts while with others, formation of nitrates occurred only in traces after a period of eight weeks. In such soil, nitrification appeared to be somewhat related with the reaction of the soil silt mixtures. At *p*H 6·2—6·4, nitrates formed were only in traces, at *p*H 6·5, the nitrates were just measurable. At *p*H values 6·9—7·0, nitrates developed were higher in amounts than what formed in Delhi soil during the period of 10 weeks.

As a result of subsequent charges following incorporation of tank silts with soil, contents of organic carbon decreased in Delhi soil, they remained somewhat the same in Guntur soil and there were increases in some cases in Jorhat soil. There were, however, evidences of appreciable nitrogen fixation in all the soils.

As a result of incorporation of tank silts with soil, the pH values of the soils decreased in the case of alkaline soil and increased in the case of acid soil. The reaction of the silt-treated soils did not appear to change very much during eight weeks.

It appeared from the investigations that application of tank silts to soil was always beneficial in the cases of soils having sandy and alkaline nature; in the case of clayey soils, some time must be allowed to lapse to cause disappearance of nitrites and in the case of acid soils liming might not be resorted to unless the pH values of the soil or silt fell below 5·5.

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APPENDIX I

Composition of Guntur and Jorhat soils
(constituents expressed as per cent on oven dry basis)

Constituents	Guntur	Jorhat
Org. C	0·37	0·43
Org. N	·066	·072
NH_4N(mg)	2·9	7·7
NO_2N	*tr*	..
NO_3N	*tr*	..
Soluble salts	0·153	0·067
pH	7·61	5·43
Sands	23·10	82·80
Silt	10·24	13·24
Clay	66·66	3·96

APPENDIX II

Composition of the tank silts
(constituents expressed as per cent on oven dry basis)

Contents	Aurangabad	Kalyanpur	Kulpi	Maldah	Noada	Rajnagar	Sirshia	Suri
Org. C	2·69	1·56	0·98	2·61	2·41	2·84	2·55	2·86
Org. N	0·249	0·166	·120	0·194	0·260	0·218	0·270	0·282
NH_4N	·016	·019	·013	·030	·019	·019	·020	·018
pH	7·20	6·60	6·68	5·19	7·58	4·81	6·38	6·58
P_2O_5	0·37	0·21	0·23	0·19	0·13	0·12	0·28	0·28
K_2O	·85	1·00	1·23	·71	1·13	·76	·78	·97
CaO	1·29	1·12	0·12	·23	3·07	·53	1·32	2·19
Sands	63·62	27·06	31·40	46·32	52·12	39·61	54·40	48·92
Silt	..	47·31	41·00	36·33	29·99	32·40	26·40	30·43
Clay	36·38	25·64	27·70	23·33	17·89	27·99	19·10	20·65

REVIEWS

ECONOMIC SURVEY OF ASIA AND THE FAR EAST, 1951

(*Published by the Department of Publication Information, United Nations, New York, pp. xxix+400, Price $2·50*)

THE Economic Survey of Asia and the Far East is the fifth in a series of annual economic reports prepared by the Research and Statistics Division of the Secretariat of the Economic Commission for Asia and the Far East. These reports have already established a reputation for comprehensive review of economic conditions in the E.C.A.F.E. region. The present report which deals with the economic developments in the E.C.A.F.E. region during the year 1951 is equally good as the previous ones. In this survey, coverage of E.C.A.F.E. region has been broadened to include Japan in it and the distinction made in previous surveys between the E.C.A.F.E. region and the A.F.E. region has been dropped.

The most pressing economic problem of the region continues to be one of ensuring adequate food production. Between 1938 and 1951 the population of the region increased by over 10 per cent, while the agricultural output had not regained the pre-war level. In contrast with the low rate of expansion of agricultural production, industrial production in 1951, on the whole, increased significantly over the 1950 level.

Generally speaking, the economies of most of the countries in the region are neither diversified nor elastic. Hence, the economic conditions of several countries in the region in 1951 were especially affected by fluctuations in the external demand for their export commodities, the effects of which overshadowed the changes brought about by internal factors. The causes of these fluctuations, including sudden increase and subsequent slackening of demand for stock-piling and rearmament, are described in a masterly manner in the text of the survey, but their consequences deserve to be underlined. The survey has made various useful suggestions for keeping the economies of these countries on an even keel and among other things has rightly pointed out that in order to prevent a recurrence of wild fluctuations in demand for and prices of raw materials, the industrialised countries should maintain a high and more stable level of activity within their own economies in which will be reflected a high and more stable demand for the primary products of the E.C.A.F.E. region. Besides, the raw material producing countries should develop flexible economic policies aiming at a larger measure of internal stability in times of depression in world markets, with a view to increasing, as far as possible, their foreign exchange reserves in times of export booms so as to avoid reduction in the quantum of imports when the export earnings are on the decline. (N.M.B.)

A GENERAL ECONOMIC APPRAISAL OF LIBYA

BY JOHAN LINDBERG

(*Published by the Department of Publication Information, United Nations, New York, 1952, pp. 55, Price $0·60*)

THE publication under review has been prepared by Mr. Johan Lindberg who was deputed by Technical Assistance Administration of United Nations to

carry out an economic survey of Libya for the purpose of working out a long-term programme of providing technical assistance to the country.

It is divided into three parts. After giving some factual information about the people and the social institutions in the geographical background in the first part, the author examines in the second part—the present economic structure of the country. The third part of the book is devoted to the problems of economic development and economic policy which will be most appropriate for the achievement of that end.

Libya is one of the most backward countries. According to the author, agriculture is the mainstay of the Libyian economy and it will continue to be so for a long time to come. Besides, the country is extremely poor in industrial raw materials. Her poverty in industrial raw materials is so great that there are practically little prospects for industrial development which is also hampered by the almost complete lack of fuel, water power, savings and mechanical skill. The state of public finance, banking system, credit facilities also present a gloomy picture.

It is, therefore, only natural that the development of agriculture which is the chief economic asset of the country should be given the highest priority by the author. Food production requires to be increased for meeting domestic needs as well as for creating export surplus necessary for paying for the import of non-agricultural products. The other directions in which development is required are livestock industry, tree crops, forestry, local industries for the processing of agricultural and fishing products, tourism, etc.

The most important point made by the author in his report is the dependence of Libya upon foreign aid. The deficits in budgets which have been a regular feature of the country are likely to increase in the years to come, in view of the expected increase in expenditure on administration and developmental activities. The existence of an independent Libyan State, it is emphasised, depends upon the receipt of grants-in-aid, their disappearance would depress further the standard of living, already close to the barest minimum required for subsistence. (S.R.S.)

COMMUNAL LAND TENURE

By Sir Gerard Clauson

(Published by the Food and Agriculture Organisation of the United Nations, Rome, 1953, pp. 57, Price $0·50)

THIS book is one among a group of land tenure studies published by the F.A.O. for the purpose of clearing cob-webs in our minds on the difficult problems connected with land tenure.

In order to explain communal tenure the author divides it into three types, primary, secondary, and tertiary. The first is the kind prevailing among people who have never conceived of the idea of individual ownership of land ; the second prevails among people who have conceived the possibility of individual rights in land but who still consider such rights as an exception and as subject to reversionary

rights of the community as a whole. Tertiary tenure is that where people either voluntarily or compulsorily join together to exercise land rights in common. We in India are essentially interested in the last-named tenure but are in for a severe disappointment here for the book deals with communal land tenure without any detailed discussion of communal farming as such. The reader who eagerly follows the story of the evolution of land tenures and who wants a connected account of tertiary tenure which implies not only communal ownership but also communal operations in farming finds that this is regarded by the author as outside the scope of the book. The author promises that such tenure will form the subject of a separate study, but the study of communal land tenure without communal farming being necessarily attached to it remains a great handicap for the Indian reader of the present publication. The only early form of tertiary communal tenure which the author comes to mention is the land system of the Incas tribe in Peru. He also touches, but just only touches, upon the Russian *Mir*. There is also a reference to the modern Israelite organisation of *Kvutsa* in the last chapter but there is no detailed discussion even here.

Having described with the limitations pointed out above, the various kinds of communal land tenures, the book goes on to discuss next the advantages and disadvantages of such tenures. Here unfortunately the discerning reader is apt to find that there is one difficulty. The author is an out and out admirer of individual or family activity writing on group activity. Whilst there is considerable depth in his observations and his scholarship need not be doubted one can certainly question some of his viewpoints. The author holds for example that 'after all the individual or family rather than group activity is the normal behaviour of mankind.' When this is applied to the very primitive tribal period one wonders whether there is not here a streak of excessive love of individualism colouring the picture specially when it has to be admitted even by the author himself that primitive man had strong gregarious instincts. The author believes that large-scale operations require organisational abilities which were not present in the primitive life of man and therefore individual specialisation was the rule even then. Perhaps we forget that in view of the simplicity inherent in the nature of operations expected from primitive man his gregarious instinct more than made up for the lack of what we call 'organisation'.

In a theme of the kind discussed here the economics of communal land tenure is fundamentally important for all concerned for whom the book is meant. Unfortunately the separation of communal cultivation of land from communal tenures makes this important discussion rather one-sided as we see here when the author discusses, among other things, the problem of excessive sub-division of land. He comes to the conclusion that such excessive sub-division 'is not related to any particular form of land tenure'. He regards communal pastoral rights as the most communal form of land tenure and comes to the conclusion that sub-division can occur in the most communal form of land tenure. Surely the most communal form of land tenure is one where the land is not only owned in common but also cultivated in common and if no individual is permitted any right of private possession there

ought to be no fear of sub-division at all in the sense in which it is spoken of here. A proper balancing of the economics of communal farming with those of communal tenures when we discuss such problems as this, is urgently called for.

In spite of the basic handicap and weaknesses pointed out above, the book is extremely useful and is worth a study by every student and critic of land tenure. The author has to acknowledge the fact that consolidation of holdings is a good solution for fragmentation *only when* there is no excessive pressure of population on the land. Many in India who rely too much on consolidation and who in their ignorance mix up solutions for sub-division of land with remedies meant only for fragmentation will profit from such timely warnings as these. It is interesting to note that in spite of what looks like an undoubted bias in favour of individualist agriculture the author recognises the advantages of communal tenures (even without communal cultivation) in matters such as excessive indebtedness, destruction of soil fertility through individualist poverty or negligence, land speculation, etc. In case of indebtedness, for example, the most typical form of indebtedness is created by mortgage. Obviously not even the author can ignore the fact that creation of mortgage rights to own lands is simply not possible when we have real systems of communal ownership. (P.N.D.)

CADASTRAL SURVEYS AND RECORDS OF RIGHTS IN LAND

PREPARED BY BERNARD O. BINNS

(*Published by the Food and Agriculture Organization of the United Nations, Rome, 1953, pp. 67, Price $0·50*)

THE publication is a study on land tenure. As stated in the foreword, the study which is based on existing and readily available information can be regarded as a preliminary paper in which subsequent research and action can be based. The subject is dealt with in the following sections :—

(1) Soil survey and maps
(2) Cadastral maps
(3) Air survey and cadastral maps
(4) Registers of rights
(5) Principles to be followed in the preparation and maintenance of records of rights
(6) Direct advantage of cadastral surveys and registration of rights
(7) The place of cadastral surveys and registration of rights in rural development

The paper lays stress on the importance of large-scale maps for the success of agricultural and rural development programmes and justifies large-scale survey and cartography for a proper record of rights, privileges, duties and responsibilities

of a State. The status of surveying and cartography is not adequate for the development of natural resources in most of the countries of the world, because, so far, the objective has been the primary needs of the army. No progressive country can afford to deny itself the advantages which derive from an accurate large-scale survey of its land, preferably on a scale of $4' = 1$ mile and from a precise and up-to-date records of the rights held therein. Particular stress has been laid on air survey and cadastral maps. There is a detailed discussion and examination of the nature and scope of land surveys and records of rights and the more important purposes served by cadastral and other large-scale maps and by systems of registration of rights in land from the point of view of land reformer, the land holder, the Government, agriculture, economic development generally and the general public. The cost of maintenance of maps and of the preparation and maintenance of records of rights is not prohibitively expensive as these will be recouped in the advantages derived from the existence of the maps and records. The subject has been presented in simple language, and will prove quite useful to all interested in general agriculture and land reforms. (S.P.R.)

MANUAL OF CANE GROWING

By Norman J. King, R. W. Mungomery and C. G. Hughes

(*Published by Angers and Robertson Ltd., London, W.C.1., pp. 349, Price 63s.*)

THIS is a very well written publication. It is, according to the authors, primarily intended for the small cane grower in Australia, who may not have access to the publications of other cane producing countries. It is intended to supplant the 'Queensland Cane Growers Handbook' published by the Bureau of Sugar Experiment Stations in 1939 and which is now out of print. The new book contains up-to-date information on varieties, weedicides, pests, diseases, etc.

The sugar industry in Australia, though comparatively young, is perhaps the most highly mechanised sugar industry in the world. 'In this mechanical age, the operation of hand planting is rarely seen except when a farmer supplying gaps in a planted field.' The most interesting feature is the invention and adaptation into cultivation of small-scale mechanised implements. Details have been given in the manual of the various implements in vogue as also a history of the older ones now replaced.

The merit of the manual lies in the successful attempt made to post all the information to the grower to ensure a well grown sugarcane crop and avoid many of the pitfalls. It covers the ground necessary for an understanding of the different aspects of cultivation and the scientific reasoning behind the many recommendations made. Technical terms have been kept at a minimum and this presumably explains the omission of the technical names for the different diseases, pests and many of the green manures.

Though much of the information contained especially regarding mechanised implements, is of direct value mainly to the Australian cane grower, the basic principles of cane cultivation being the same everywhere, the manual should serve as a valuable reference book. Certain of the recommendations made are of importance to the cane grower in all countries. Emphasis has been rightly laid on the conservation of the organic matter and its incorporation with the soil. The scientific use of manure has been stressed and the service rendered by the Bureau of Sugar Experiment Stations in analysing the soil types in the sugar belt and recommending planting and ratooning mixtures is worthy of commentation. The balance use of fertilisers especially of ammonium sulphate for ensuring a good stand quality crop has been emphasised. Ratooning is regarded as an essential part of the economics of cane cultivation and taking of two ratoons seems to be the normal feature. The necessity of careful and painstaking cultivation of ratoon (not treating them as 'catch crop') and the operations connected therewith have been well brought out. The successful use of weedicides especially as pre-emergence treatments makes it important to try these on a systematic and field scale under Indian conditions.

Two well written chapters have been devoted to diseases and pests prevalent in Australia. The information contained regarding the symptoms, seasonal incidence and control measures to be adopted would benefit the grower in the early detection and timely control of the diseases or pests.

One chapter has been devoted to 'Cane Varieties and Cane Breeding'. Short notes on the agricultural characteristics of the thirty varieties in cultivation have been given. Perhaps a short description of the botanical characters of these would have been helpful to the grower in the proper identification and cultivation of the proper variety.

The large number of illustrations and quite a few colour plates enhance the value of the manual. Particular care has been taken to illustrate through the photographs the damage caused by diseases and pests and the efficacy of weedicides which should convince the grower of the necessity for following the directions contained in the book.

The arrangement of the chapters is systematic and speaks of the pains taken by the authors in the preparation of the manual. The printing and get-up of the book is good. For the purpose intended, as brought out in the preface, the manual should serve as a valuable guide. (N.L.D.)

LIST OF SUGARCANE INSECTS

By H. E. Box

(Published by the Commonwealth Institute of Entomology, London, 1953, pp. 101, Price 15s.)

THE first part of this book is a catalogue of sugarcane insects and mites which have been recorded in the world so far. The list is fairly comprehensive and contains very useful information about the systematic position of the pests concerned, the countries in which they have been recorded and the parasites and predators known to attack them.

In Part II of the book the parasites and predators are listed showing their hosts, the countries in which they attack them and those into which they have been introduced.

There is a very useful bibliography appended to the list. Considering the scope of the work, it is not surprising that a few publications including some on Indian fauna could not be listed. It is gratifying to note that most recent names of various sugarcane insects, mites, their parasites and predators have been used in this publication, which should prove very valuable to research workers in all sugarcane growing countries. (H.S.P.)

WEED CONTROL

By W. W. Robbins, A. S. Crafts and R. N. Raynor

(Published by McGraw Hill Book Co., Inc., New York, 1952, pp. 50)

THIS is a second edition of the well known text-book on weed control first published in 1942. In view of the fact that 'more progress has been made in weed control during the past decade than in all agricultural history prior to this period,' this edition has been substantially revised and brought up-to-date without making the book bulkier—in fact the number of pages has been reduced by forty. This edition contains 24 chapters as against 26 in the previous one and the economy in space has been achieved by omission of some details and some rearrangement, without prejudicing the continuity of the subject matter or the scope of information. The incorporation of much new and useful information on properties and functions of herbicides and on their application to various crops deserves special mention and the treatment of the subject throughout is clear and lucid.

This volume should prove useful to ecologists, plant physiologists and agronomists and should find a place on the shelf of every library that caters to their needs. The get-up of the book, as is usual with the McGraw Hill publications, is excellent. (R.D.A.)

WOOD PRESERVATION

By G. M. Hunt and G. A. Garret

(Published by McGraw Hill Book Co., Inc., New York, 1952, pp. 417, Price $7·50)

IT is a great pleasure to all the workers in the field of wood preservation to see the second edition of the text-book 'Wood Preservation' by G. M. Hunt and G. A. Garret. It was first published in 1938 and even then the subject matter was so thoroughly and masterfully dealt with by the authors that no room was left for any revision during the last 15 years. In the second edition, the subject matter and the division of the book into the various chapters are the same. But, valuable additions have been made to each chapter thus bringing a compact mass of recent developments in the researches on wood preservatives, wood preservation processes, wood preservation plants, and methods of testing preservatives in the laboratory and in the field before the reader. The get-up of the book is attractive. It would

have been excellent if the authors had collected the activities of various countries in the world in the development of wood preservation industry and given a short account of the progress made and the economic advantages gained therefrom so as to give a fillip to the countries which have not adopted wood preservation on a commercial scale. It would have also been very useful if the addresses of firms dealing with wood preservation plants in the U. S. A. and Europe were given along with rough quotations. These remarks are meant to add more value to the book but in no way detract the value and the usefulness of the present edition. The book is a valuable asset to the teacher, to the research student and the businessman dealing with wood preservation. (A.P.)

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In the case of botanical and zoological names the International Rules of Botanical Nomenclature and the International Rules of Zoological Nomenclature should be followed.

Reference to literature, arranged alphabetically according to authors' names, should be placed at the end of the article, the various references to each author being arranged chronologically. Each reference should contain the name of the author (with initials), the year of publication, title of the article, the abbreviated title of the publication, volume and page. In the text the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets, when the author's name occurs in the text, the year of publication only need be given in brackets. If the reference is made to several articles published by one author in a single year these should be numbered in sequence and the number quoted after year both in the text and the collected references.

If a paper has not been seen in original it is safe to state original not seen. Sources of information should be specifically acknowledged.

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